THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 38. Thursday, February 2, 1928. No. 598.

PUBLISHED WEEKLY

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telephone: Gerrard 3961 (4 lines).
Telegraphic Address: "Zacatecas, Rand, London."

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

FEBRUARY 7.

Institute of Metals (North-East Coast Local Section):—Ordinary meeting at Newcastle-on-Tyne. J. A. Smythe, D.Sc., Ph.D., and C. E. Pearson, M.Met., demonstration of mechanical testing of metals.

Staffordshire Iron and Steel Institute:—Combined meeting at Birmingham. "The Testing of Metals," Paper by W. R. Barclay, O.B.E.

Sheffield Metallurgical Association:—Ordinary meeting. "The Diffusion of Carbon and Nitrogen in Iron and Steel," Paper by A. Bramley, D.Sc., A.R.C.S.

FEBRUARY 8.

Institute of Metals (Swansea Local Section):—Ordinary meeting at Swansea. "Gases in Metals, with Special Reference to Copper," Paper by N. Alan, M.Met.

FEBRUARY 10.

Institute of Metals (Sheffield Local Section):—Meeting at the University, Sheffield. "Casting," Paper by J. B. Forster, M.Sc.

Institute of British Foundrymen.

FEBRUARY 9.

Birmingham, Coventry and West Midlands Branch:—Ordinary meeting at Birmingham. "The Engineering Aspect of Foundry Operations," Paper by W. Rawlinson.

On Industrial Accident Prevention.

We spent some time last Friday at a congress organised by the Industrial Welfare Society to deal with accident prevention in industry. An admirable Paper was presented by Mr. James Smith, of Messrs. Beyer, Peacock & Company, Limited, but the only point brought out which has not previously been covered by matter which has already appeared in these columns was the prevention of littering up of the outside of workshop walls by the formation of narrow shrub beds. A second Paper, by Mr. Bernard L. Lelliott, dealt with "The Competitive Spirit in Accident Prevention," which left us quite unconvinced that it was attacking the root of the evil. A fundamental error which seems to be prevalent in discussions of this character is one enunciating that no risks should be taken. This is certainly a spirit foreign to a high-class foundryman. Are running stoppers, run outs from moulds, and awkward tap holes to be left to work out their own destiny? It is obvious to everybody in the foundry industry that risks must be taken, and it is with this assumption that accident prevention must be tackled, and as one speaker suggested, on the designing board for new plants. It is here that adequate provision can be made for lighting; for minimising the ravages due to cupola dust and fumes; for providing adequate storage of foundry plant; for the safe transport of material and the proper housing of the employees during working and lunching hours. Human intelligence up to now has evolved the following precepts for accident prevention:—(1) The various Factory Acts; (2) the amelioration of sanitary conditions; (3) adequate lighting, heating and ventilation; (4) the maintenance of clear gangways; (5) the stacking of material; (6) propaganda by (*a*) posters and (*b*) competitions; and (7) by the stressing of conditions peculiarly dangerous in any one industry such as dampness of material likely to be touched by liquid steel in the foundry trade. It was stated by several speakers that many of the Safety First posters were an insult to the intelligence of the British artisan—a sentiment which we wholeheartedly endorse. Many apparently were of opinion that education, whatever that may mean, will largely reduce industrial accidents, but unfortunately it will not.

There always has been and always will be a type of individual who is "always in the wars." He is first noticed at a children's party, then on a sports ground, then in the shops, on a hunting field or a road accident. It is not fate; he merely belongs to a class of individual who is unfortunately devoid of an inherent "safety first" sense. Slogans for "safety first" are older than the present industrial era. "Look before you leap," and "A stitch in time saves nine," convey basically the same message as the modern slogans, "A cat has nine lives, but you have only one," and "Is it safe?" It is surely appropriate in this enlightened age to say exactly what we mean instead of paraphrasing ancient Greek philosophy. Reference to extraneous matter such as the lives of cats detracts attention from the basic truth to be revealed and acted upon, by inducing in the mind of the reader a spirit of silly analogy and a slight recognition of the mental agility of the perpetrator. The real message of these slogans when reduced to plain English is, or should be, "Rapid logical thought before action prevents accidents." Herein, is plainly indicated the problem to be tackled by welfare officers or others who assume this duty. Its successful resolution may bring in its train a nation devoid of enterprise and national heroes. A reference in this connection to flying is sufficient.

The resoluton of the industrial accident problem will come from:—(1) A recognition that risks must be taken in manufacturing concerns; (2) a form of mental education at present non-existent which will train the brain to operate logically under conditions of monotony and stress; and (3) erudite and expert management which will eliminate hazards outside the control of the operative.

Metallurgical Progress in Foundry Matters.

One is apt to gather from Mr. Young's talk to Sheffield foundrymen that the industry has not made, and is not making, much progress, but in reality, reading between the lines, there is revealed the fact that a forward movement has been steadily operating to the betterment of the trade.

"Before the war they (foundrymen) hardly knew their names (graphite and pearlite)" and "curly graphite" are but two quotations which indicate that an inquiring spirit is abroad, and represents one which leads to true progress. When all is said and done, the sole factor which can and will make for improvement in the industry is for it to become rich. This can be accomplished either naturally, through a trade boom, or rationally, by co-operative effort designed to eliminate waste of material and effort. Those who by long years of contact know the industry thoroughly are loudest in their praise of the change which has come over the trade in the last two decades. No longer does a foundryman condemn a consignment of coke as not being of the nature which will blend with his pig-iron mixtures. It is now quite easy to find foremen who can calculate their mixtures from the chemical analysis of their raw materials. Again, whilst it is not universal, there is a better conception of cupola practice, whilst the antipathy to moulding machines and other modern plant is largely non-existent. To those who would advise the foundries as to their future conduct should realise that there is, generally speaking, a real desire to improve the conditions at present existing in the industry.

XUM

Institute of British Foundrymen.

LONDON JUNIOR SECTION.

A successful meeting of the above was held at the offices of The Foundry Trade Journal, 49, Wellington Street, Strand, W.C.2, on January 27. Mr. P. Ellis (Chairman) presided over a good attendance, and a Paper entitled "Casting" was read by Mr. Leonard Howell.

Development of Casting Processes.

The Paper opened with a historical summary commencing with the production of castings in moulds in the early Bronze Age, showing that "permanent" moulds used to-day were not of recent introduction.

The various factors which affected a casting, namely, composition, temperature, impurities, design, etc., were touched upon, after which the lecturer went on to explain the various types of casting, including die-casting, in which case a list of the alloys and their compositions and properties was given. Slush casting, Cothias casting, centrifugal, permanent mould, and sand casting were all dealt with in turn, the lecturer pointing out how, in the case of sand casting, greater responsibility was called for on the part of the moulder than in the case of other processes, where the runners, risers, etc., were already designed, and, therefore, the moulder was only responsible for the actual pouring.

The methods of gating castings were considered, the lecturer favouring the drop gate as being useful for thin castings of large area as well as for heavy castings with variable thicknesses. In some cases a cleaner and sounder casting could be obtained when the metal entered the mould at or near the bottom. Core gates were useful when it was desirable to fill the mould by a gentle stream of metal from the interior.

Passing on to non-ferrous sand casting, it was stated that the lower the casting temperature (other factors being constant) the greater would be the hardness (Brinell). In the case of bronze, variations in the casting temperature had a marked effect upon the colour of the fracture of the metal. When the strength of a cast alloy was of primary importance, the conditions which tended to give a bronze the greatest strength were rapid solidification from a fairly low temperature and very slow cooling after solidification. A long discussion followed.

The Chairman announced that on Saturday afternoon, February 11, members were invited to visit Messrs. Fraser and Chalmers' engineering works at Erith, Kent.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

American Practice in Britain.

To the Editor of The Foundry Trade Journal.

Sir,—I quite agree with Mr. Sherburn when he said that Mr. Longden's Paper would be read with more advantage before an employers' association, because mass production involves a very large outlay of capital. It would not be a commercial proposition for the majority of British foundries, because they are mostly of the jobbing variety, and deal with a continual alteration of designs. This is why British moulders will always be superior to the American.

Furthermore, the British moulder does not take kindly to any mechanical appliance that is put in the foundry for his benefit. In one foundry a Slinger was installed, and it was hard work to convince the moulders that it was a benefit to them by saving them hours of hard ramming. They have the idea that it means less men required, but actually new mechanical apparatus brings more trade. At an old-established foundry the writer installed a moulding machine, and all the moulders were under the impression that some of them would be dismissed, because the firm only made their own castings. However, almost immediately outside orders were taken on, and more machines put into the shop. There is at least one American firm in England that is working on mass production lines. Even their moulding machines, core-shells, core-boxes, snap flask fittings, plates for pattern mounting are made on mass production. Although this firm have not, as yet, installed a sand conveying system, the moulders made on average 20 to 22 moulds per hour in 18 in. × 12 in. × 5½ in. and 18 in. × 10 in. × 5½ in. boxes, and this is done by youths of 18 and 19 years old who had not seen the inside of a foundry before.

The facing sand is mixed and taken to them and the backing sand is screened at night, thereby giving them a clear run for the day. They also cast the moulds themselves. This emphasises that British workers are as good as, if not better than, the American, who mostly are British in origin. At this foundry the writer stated that the American could not produce a finish equal to the British, and this can be taken as proved, because some castings have been exported to America as an example of what excellent skin is produced in England.

Yours, etc., F. Rogers.

5, Avondale Road, Ipswich.
January 24, 1928.

***Re* A Cast-Iron Shoot.**

To the Editor of The Foundry Trade Journal.

Sir,—In reply to "Seestu's" letter in your issue of January 12, your correspondent says:—"A more suitable method is as follow," etc. My reply to this remark is in "Seestu's" judgment only; but other people have opinions, and are equally as well qualified to express them. However, the reason the core was made in dry hard loam, and not in green soft sand, was merely to prevent the moulder ramming out of shape or marking the mould, which happens on many occasions. The matter of drying in some shops is a mere detail owing to such good conditions; in others, perhaps having one or two or three stoves only, and probably placed in awkward positions, this tends to create difficulties.—Yours, etc.,

"Sprig."

January 31, 1928.

Institute of Metals.

Opening of New Offices.

The twentieth annual general meeting of the Institute of Metals, which will be held in London on March 7 and 8, will include several interesting functions. Thus the new President, Dr. W. Rosenhain, F.R.S., will be inducted into the chair by Sir John Dewrance, K.B.E., and will deliver his Presidential address. Afterwards sixteen Papers will be read and discussed. These include contributions from metallurgists in Germany, Japan and the United States, as well as Great Britain. Following the Papers there will be a dinner and dance at the Trocadero Restaurant, also the formal opening of the new offices and library of the Institute at 36, Victoria Street, London, S.W.1. The official programme of the meeting includes a notable list of new members—123 in all—which brings the membership close to the 2,000 mark. It is striking to note what a large proportion of the new members reside abroad. An election of members is announced to take place on February 22; particulars of membership, which now covers the period ending June 30, 1929, are obtained from the Secretary, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, London, S.W.1.

The assets of Messrs. Kryn & Lahy Metal Works, Limited, the well-known manufacturers of steel castings, have been purchased by a strong and active group of business men, who intend carrying on the business with the utmost energy. A new company, the name of which will be made public a few days hence, is in the course of formation, and Mr. J. Deschamps and Mr. Abel have been appointed joint general managers.

The ironfoundry until recently conducted by Marsden & Naylor, of Skipton, who specialised in gearing and employed 50 men, has been acquired by David King & Sons, Limited, of Glasgow, who expect to reopen the foundry in February for the making of lighter casting for railway bridges, lamp-posts, gutters, pipes, etc. Work is expected at first for about 50 men, but extensions are contemplated. The works, which are at Foundry Field, were erected in 1920.

Random Shots.

Wireless, it appears, will not much longer be confined to the valuable but onerous task of supplying the general public with something to criticise. We have recently been offered the quite enchanting prospect of traffic control by radio, and weighty discussion has also been taking place on the matter of the competition of beam wireless with the world's existing cable system.

* * *

The great advantage of the cable over the wireless, it is suggested, is the greater possibility of secrecy, within the Empire at least, in times of emergency. The problem immediately under consideration, however, is more a matter of private enterprise versus government control, and hopes are entertained of "a common policy being adopted by the various Governments concerned."

* * *

But in one quarter at least scientific development—or perhaps we should say one of its more or less legitimate offspring—has received a check, and a check that will not be universally unpopular. The proposal of a northern syndicate to establish fox-terrier racing with an electric rat has been turned down. . . . The refusal was based on various perfectly sound reasons, but it seems not improbable that at least some weight may have been given to the known fighting propensities of the fox-terrier. . . . If even a greyhound can give the pugnacious public a run for their money—although not exactly the kind of run they came to see—an arena might possibly be a more suitable setting for terriers than a racing track. . . .

* * *

It is unusual for professional candour to go as far as that of the showman who was hailed before the magistrates for running games of chance. He endeavoured to prove that réal skill was required, and when it was pointed out that, on the contrary, every player took his chance, he declared indignantly—"But they don't—they have no chance at all!"

* * *

Scepticism is not infrequently expressed as to the value of "suggestions schemes" operating in works and business organisations generally. The London Underground Railway has just made public some interesting figures in this connection. During December last, 483 ideas were submitted by employees, 72 of which were considered worthy of adoption. This is almost exactly one-sixth of the total, and in itself quite a considerable figure. We are not, of course, given any indication as to the importance, the scope, or the nature of the suggestions made, but these figures do at least suggest that the scheme can be made to yield very considerable advantages.

* * *

The latest figures from the Ministry of Labour Gazette are also illuminating in their field—which is to most of us a somewhat more important one. The unemployment figures for 1927 are the lowest since the year 1920, while the number of trade disputes totals 303—a figure which seems quite bad enough until we go on to read that it is the lowest for forty years. No doubt the events of 1926 can be felt here, but so definite a drop in unemployment is hard to explain by any other means than that of a more promising state of trade generally—and one is inevitably cautious about admitting that as a possible explanation of anything.

* * *

Those who are interested in questions of Empire trade will have noticed that trade commissioners from the chief Dominions are visiting or about to visit this country in order to go into the matter of our exports to them—with especial reference, we are told in one case, to certain heavier branches of industry. These commissioners will discuss the questions raised with various Chambers of Commerce and with leading manufacturers interested in export business.

Marksman.

Colonel H. S. Evans has been elected a director on the London board of Amalgamated Zinc (de Bavay's), vice the late Mr. H. W. Pelham Clinton.

A Discussion on Pattern-making.

Many interesting aspects of pattern-making were brought to light in a discussion which followed Mr. Furmston's Paper on this subject printed in our issue of January 19. It was opened by MR. J. W. GARDOM, who, commenting on the exacting nature of the pattern-maker's work, said that only that day he had sent instructions to his pattern-maker to alter a chain to the extent of half an inch in 10 ft. There were 130 castings in 10 ft. of chain, so that each pattern had to be altered $\frac{1}{260}$ part of an inch, and that was asking a great deal of the pattern-maker. That, however, was one of his specialist jobs. An essential point about Mr. Furmston's Paper was that it was written by a specialist on a specialist subject, and we are all becoming specialists. Some years ago it was considered that every engineering shop should have its own foundry and pattern-making department. Later it was found that it was far better to hand over to founders generally the work of producing castings, and for the engineers to buy from them; and now these founders were beginning to realise that it was far better for them to buy their patterns from pattern-makers rather than to make their own patterns. The main trouble experienced by the iron-founders was that if they made their own patterns the pattern-makers had little to do perhaps for three weeks, and then had three weeks' work to get out in the following week. He asked Mr. Furmston if he had ever been called upon to supply a drier for a core. One made core-boxes with a pattern, but when the core was made it was often found that it would sag, and something had to be done to help it retain its form during the drying. A good drier would often save much core-making and intricate core boxes. Referring to the production of shoddy patterns, for which, he agreed, the jobbing pattern-maker was more or less noted, Mr. Gardom expressed the opinion that the production of such patterns was due entirely to the fact that founders and engineers demanded cheap patterns, and he suggested that if only they appreciated the ultimate saving of a good pattern they would not grumble about paying a proper price. At present they seemed to be content to pay £5 (unestimated) for a pattern made inside the works and 5s. for a similar pattern made outside. He asked Mr. Furmston if he could estimate within a reasonable degree of accuracy the cost of a pattern, so that he could really feel that, when asked to quote a price, he was quoting one with which he would be quite satisfied. He had never yet found a pattern-maker who could do that.

Piece-Work Pattern-making.

Again, he asked Mr. Furmston if he could suggest a piece-work system applicable to pattern-making. The only one he himself knew of as being possibly workable—he had not yet dared to put it into operation—was to give the men a bonus based on the number of days that a job remained in the shop. It would vary, of course, in the different shops. For instance, in some shops where one usually gave a delivery period of four weeks, other people would give a delivery period of perhaps ten days. If one were given a period of four weeks one would want the pattern out of the pattern shop in five or six days. His suggestion was that every job that went into the shop should go through in rotation, and that the men should be given a bonus on every one that came out in five days—assuming that were the basis time. Some jobs, of course, would take only half an hour, whilst others would take a few days, but they would even themselves out. If Mr. Furmston considered that that system was of no use, could he suggest a better one?

MR. JAMES ELLIS (Past-President of the Institute), speaking from the point of view of the moulder, said many people had held the opinion that the pattern-maker was a necessary evil, and a non-producer, but, however that might be, he was a very important man, and if he could produce a pattern which the moulders could mould from, the latter were joyful. In a criticism of some patterns which Mr. Furmston had exhibited, he suggested that the prints should be reversed in order to make it easier to locate the cores. Another criticism was that, although the pattern-makers grumbled at the moulders for driving spikes into the patterns in order to rap and draw them, with the result that the patterns were wrecked beyond recognition, the pattern-makers did not always make provision for rapping. He pointed out that two of the patterns exhibited by Mr. Furmston had no such provision.

MR. G. C. PIERCE (Past Branch-President), dealing with the question of the payment of the pattern-makers, said that although it was sought to introduce payment by results into foundries—and he had heard many arguments for and against it—he had never been able to understand why a pattern-maker did not stand on the same plane as a foundryman in that respect. The only difference he could think of was that it might be a little difficult for a pattern-maker to estimate absolutely correctly how long it would take him to produce a pattern, the like of which he had never seen before. He disagreed with Mr. Furmston, therefore, in this matter. He was not concerned as to whether the pattern-makers worked on a system of payment by results or not, but he felt that if it were possible for every other section of the engineering industry to work on such systems—and he knew of no other section which did not—it should be possible also for the pattern-makers to do so. He knew why they did not, but he did not see why they should not.

Colouring Patterns.

MR. V. C. FAULKNER (Past-President of the Institute) asked whether Mr. Furmston had standardised his system of colouring patterns or whether he used the systems indicated to him by his customers.

MR. A. R. BARTLETT said that in these days of mass production cores were made on core machines, and he asked if it was not advisable to make the print the right size at the base, with the taper added to the print, where joining the body of the pattern, thus avoiding the necessity for grinding the core to a taper, which was always a difficult matter. With regard to colouring, he asked if it would not also be advisable, in the interests of the general foundryman, to have a universal scheme of colouring. In the case of iron castings, for instance, the patterns could be painted black, the core prints yellow and all machining surfaces red. That would be a great help to the foundryman, especially the jobbing foundryman, because in order to produce a casting successfully he must know which were the machining surfaces.

Contraction of Metal Patterns.

MR. W. F. HART asked for further information with regard to metal patterns, because one of his greatest difficulties was to find a good metal which would stand the wear and tear of the foundry and which would not contract, so that one could make a good pattern from the pattern sent by the customer. He had tried a good many different metals, but had not yet found one which was really satisfactory, and which would obviate the necessity either of making a new master pattern or of spending a lot of time patching up the pattern cast from the customer's pattern.

MR. A. F. GIBBS disagreed, from the economic point of view, with Mr. Furmston's suggestion that it was not advisable to have loose pieces on patterns mounted on machines, and that it was better to core out. Very often it was not advisable to core out, and where one had a loose piece dovetailed in with the pattern everything worked satisfactorily. Referring to the problem of paying pattern-makers, he said that about 24 years ago he had worked in a shop in the eastern counties where the pattern-makers worked on piece rates. Mr. Furmston had been very modest in his reference to the mounting of patterns on plates. No details had been given of the costs of metal and wooden patterns, and it would be enlightening if Mr. Furmston would state how many wooden patterns could be made for the cost of one metal pattern. The pattern-makers' foreman and the foundry foreman at his works had come to the conclusion that it was cheaper to mount wooden patterns on plates, because thousands of castings could be made from one wooden pattern. It seemed to him, therefore, that Mr. Furmston had rather over-stated the value of the metal pattern, and that it might be advantageous to push the wooden pattern,

Guaranteeing Output from Patterns.

MR. C. H. KAIN asked Mr. Furmston where he considered the liability of the pattern-maker started and ended. The average pattern-maker received a drawing, looked at it, and then went to the foundrymen and asked how they wanted it made, and they had to advise him on details. With regard to American practice, he said that firms there were specialising in pattern-making. A pattern-making firm would receive a blue-print, make the pattern in a certain way, to suit the methods of work in the customer's shop, and gave a guarantee of production; *i.e.*, they undertook that it was finished so perfectly and made in such a way that if it were put into production on a certain type of machine, or if hand moulding were adopted, a certain number of castings would be produced from it. He knew of no such practice as that in this country, and he asked Mr. Furmston if he had ever attempted to do anything of the sort.

MR. O'KEEFE (Birmingham) aptly described the foundry as the kitchen garden of the engineering industry, as from the foundry grew the castings, which, after passing through the various shops, reached the world's markets. He stressed the importance of intelligent co-operation in foundry organisation; he knew that amongst the serious troubles in foundries little differences often produced a useless condition of internecine loggerheads. He did not think that those responsible for the design always gave sufficient consideration to the intricacies of the foundryman's work. Designers who were thoroughly conversant with the work of the foundryman eliminated in their designs whatever they knew would embarrass the foundryman or interfere with the facility of his work.

The designers' intentions called for thoughtful application by the pattern-maker, and he, in his turn, takes cognisance of the moulder's art. Anything which added to the difficulties of these fundamental workers added to the cost of the finished article.

Not infrequently, Mr. O'Keefe said, he was asked to give the benefit of his experience to manufacturers where the foundry department had become a difficult one. He gave a typical instance quite recently, where, on investigation and test, he readily discovered that there was a lack of sympathy between every member of the foundry department and the management. In one afternoon he satisfied the manufacturers that, without adding to the cost or general labour, by bringing the men together and letting each thoroughly understand what was expected of him, and well within his capacity, the production increased three times. In that case the material was good, the workmen were good, the pay was good; merely a lack of co-operation and sympathetic understanding was the cause of the trouble.

He urged that it should not be overlooked by employers that good workmen, giving good services, deserved and could be paid good wages. If an experienced man went into the shops and let the workmen see that they were understood, and their endeavours appreciated, they did their work better, and quite unconsciously there was a repercussion in every other department of the works. Believing in the efficacy of his doctrine he had pursued that path, as his friendly manufacturers would admit, to their advantage.

Author's Reply.

MR. FURMSTON, in reply, referred to shoddy patterns, and ascribed the trouble to the present system of buying. He knew of several large engineering firms, possessing their own pattern-shops, and who ought to know something about pattern-making, and yet when they were rushed and required additional pattern-making, they sent blue-prints to outside pattern-makers, who, of course, were not so well acquainted with this particular kind of work. Some poor pattern-maker under-estimated, and received the job. The pat-

tern-maker might scamp the work deliberately or he might scamp it because he found he was losing money on it. In either case the pattern was shoddy. When the pattern arrived at the foundry, however, much time had to be spent on putting it right before it could be used; but the cost of that extra work never seemed to be booked up against the cost of the pattern, and the outside pattern-makers, who did the work cheaply, continued to receive orders. The trouble seemed to be that the buyer did not realise all the costs concerned in the matter, and the foundry people, who had to incur that extra cost in the foundry, did not make sufficient fuss about it. If they did, perhaps things would alter. He believed there would be an alteration, however, when trade improved.

With regard to estimating the price of a pattern, he said he always maintained that it involved a lot of guess-work, but it was astonishing how accurately one could estimate in many cases. He had thousands of records, and, although he was seldom called upon to estimate for another pattern similar to any one of those recorded, the records constituted a sufficient guide to enable him to estimate sufficiently accurately.

Piece-Working Systems Deemed Impracticable.

With regard to piece-work systems, he said he had never operated one; he did not believe in them, and had never heard of one which was really successful. He knew of firms who paid a bonus on foundry output, but what on earth for he did not know; it seemed to be an indirect method of paying higher wages than the Employers' Federation allowed. Those firms did not get the work turned out more quickly as a result of it, because men who he himself had dismissed had gone to those firms and had obtained employment; if they were not good enough for him, they were not good enough for the other firms. If one could find a satisfactory piece-work system it would be all to the good, but he could not see how it could be done. It was far better at present to give the men a decent wage and to hold them that way.

Replying to Mr. Ellis's suggestion that the prints on some of the patterns which had been exhibited should be reversed, said that those patterns were produced in accordance with the usual practice, and in the manner demanded by foundrymen generally. Indeed, the patterns were made to the instructions of the foundry. As to the criticism in regard to the absence of any provision for drawing, in the case of one of the patterns shown, he said that that was not a pattern made for production in the foundry; they were merely master patterns for one off only, otherwise the necessary provision would have been made.

Stencils Preferred to Colours.

Replying to Mr. Faulkner's question with regard to the lining of core-boxes with sheet metal, he said he did not mean that the moulded shape of the core-box was lined, but merely the faces on which one strickled off the sand. The metal used was usually rolled brass, about ⅛ in. thick. With regard to the height of the bench, that was fairly uniform, he believed, at about 2 ft. 8 in. It was not possible to adopt a colouring system when working for a large number of people, as in this case; some customers would prefer certain colours and others would prefer other colours. In his experience only one customer had asked for special colours, with a distinct colour for machining faces, but he (Mr. Furmston) kept a set of stencils for the machining faces of big jobs, and stencilled the words, "This side up" or "Machining face," and so on, if necessary. He did not use special colours unless they were asked for. Colouring cost money, and one was up against costs all the time.

Replying to Mr. Pierce, he said one could pay pattern-makers by results if one estimated every pattern and agreed the estimate with the pattern-maker, and that might well be a snag. A tremendous amount of time would be wasted in estimating; his experience was that the average pattern-maker would work well if treated well. Pattern-making was undoubtedly a trade in which the men usually took a great interest, although, of course, there were some slackers, and he did not think that a system of payment by results would be economical.

Non-Shrinkable Metals.

Dealing with Mr. Bartlett's remarks, he said it was the usual practice to make the core print the right size at the bottom and not at the top, otherwise one left a big fin, which meant more work in cleaning up, whereas it was not very much trouble as a rule for a moulder to rub the core taper in the print part. His experience with regard to the production of metal patterns to withstand wear was that the metals which were called "non-shrinking" were always soft metals, and they would be deformed by the moulder's rammer. In connection with the making of metal patterns, he invariably had to make the masters in the first place, and preferred to make the metal patterns in aluminium. That would stand a good deal of knocking about, and he believed it would break rather than bend. He had made patterns from which thousands of castings were produced by hand ramming, and they stood up to the work. He had known cases in which patterns made in aluminium had been sent back for alteration, and, although one could see the scratch marks on them, the scratches had never penetrated into the metal, and had not affected the shape of the patterns. Replying to Mr. Gibb's question as to the use of loose pieces when machine moulding, he said it depended rather on what was meant by "machine moulding." He was thinking of a machine in which the ramming was done by machine jarring. With hand ramming one could use loose pieces; one must ram under the loose pieces by hand, and for purposes of mass production he considered that the best plan was to put a core underneath. The mounting of patterns on plates was a fairly simple process, provided care was exercised. One must be accurate. The centre lines were marked on the plates, and the patterns must be mounted in conformity with those lines. They must be symmetrical, of course. There was far more difficulty in making a cast plate, but that was more a foundry problem, of course.

Liability of Pattern Makers.

The point raised by Mr. Kain as to where the liability of the pattern-maker began and ended was rather a sore point. Some firms expected the pattern-maker to pay for all castings which were made wrongly, but that, of course, would ruin most small pattern-makers. In any case, it was up to the buyers of the patterns to check them and to assure themselves that the patterns were right, and one could not expect the pattern-maker to pay for castings which were made wrongly from patterns which the foundryman had not checked. That was too great a responsibility for the pattern-maker, because very often the drawings were vague, and capable of being read in different ways. As to the practice of guaranteeing a certain production from a pattern, he asked what the foundries would have to say about it if it were applied in this country. He could not imagine a jobbing pattern-maker in this country producing a pattern and telling the foundry foreman that he should get a certain number of castings from it, without the foundry foreman having a say in the matter. He imagined the moulders would object. In America, of course, there was more mass production than in this country, and probably there were pattern-makers there who were more or less specialists on moulding machines, and who could make plates, particularly in regard to the more or less simple stuff, but he did not think the application of such a scheme would work in England.

Vote of Thanks.

The Branch-President, proposing a vote of thanks to Mr. Furmston for his Paper, said his experience of jobbing pattern-makers was that the bad ones were a curse and the good ones a blessing. The bad ones were a curse because they quoted ridiculous prices and made it difficult for the good ones to get fair prices for good patterns; one could not get good work out of a foundry without a good pattern. A real good jobbing pattern-maker, such as Mr. Furmston, was one of the blessings of the industry. As Mr. Gardom had said, there were occasions when the pattern shop connected with a foundry could not cope with all the work available, and it was then that the good jobbing pattern-makers of Mr. Furmston's calibre saved the situation. The jobbing pattern-makers of America were far ahead of those in this country because they were far more liberally equipped there than here. Not only did they make a pattern, but they also put it on a plate and tried it out on a machine, and as a result they were able to say authoritatively that a certain production could be obtained from that pattern. He hoped the day was not far distant when Mr. Furmston would be able to supply patterns in that way.

The vote of thanks was accorded with acclamation, and the meeting closed.

Fifty Years' Service.

On February 15, Mr. Samuel Whitmore, chief engineer for the firm of Messrs. John Lysaght, Limited, Newport, will celebrate the fiftieth anniversary of his association with the firm, which commenced at Wolverhampton, and has been continued for 28 years at the Orb Works at Newport, for the lay-out of which he was chiefly responsible, when it was decided to remove the firm's rolling mills to the seaboard. Mr. Whitmore is also manager of the Swan Gardens Works at Wolverhampton, now devoted to foundry work and the manufacture of chilled rolls for sheet mills. Mr. Whitmore during the war was largely responsible for the large output maintained at Maesglas Shell Factory, Newport, Mon., and in recognition of his services he was appointed a Justice of the Peace for Monmouthshire. He has been a member of the Iron and Steel Institute since 1903, and is a recognised authority on sheet mills and their plant.

Book Review.

Ryland's Directory (19th Edition).—Published by Industrial Newspapers, Limited, 49, Wellington Street, London, W.C.2. Price 42s. (cloth bound) or 52s. (Morocco). In reviewing this book we are taking our mind back to the time when we were in charge of steel foundries, and are trying to bring back, to recall, the use to which we put it, and also, in the light of subsequent experience, to what we ought to have derived from it. Primarily, in its 2,204 pages, there is contained the name, address and other essential particulars of the suppliers of the plant and raw material for the foundry industry, and so constitutes a real buyers' guide. For some raw materials, such as pig-iron, the approximate analyses are given of the various brands. There are listed somewhere in the region of 3,000 iron foundries, 2,000 brass and 150 steel, comprising altogether the most complete list in existence. In addition to the British lists, this new edition sets the names of the founders in Australia, Belgium, Czecho-Slovakia, Denmark, Holland, India, New Zealand, Norway, South Africa, Sweden and Switzerland. One slight error has crept into the list of steel founders, and that is through the booming of the wretched word semi-steel, with a result that four iron foundries have been included. Probably, to the founder, the greatest use of the directory is to the sales department. As the book covers the whole of the mining, metallurgical, and engineering industries, and an order or inquiry received from a buyer in one section, can be used as a pointer as to the requirements of the people in the same line of business. Thus, if a foundry finds itself in a position to supply colliery tub wheels, he will find a complete list of the coal-mines of the world, except the United States of America. For many industries a number of the works possess their own foundries, and only a complete work of reference like Ryland's can indicate whom to approach with confidence. There is just one other little matter to which we take exception, and that is the continuation of the use of the word colonial when dominion should be employed, and we hope this will be changed in the next edition. Other features worthy of note are the inclusion of extensive lists of telegraphic addresses; brands, trade marks and trade names; trade associations. It is not generally known, but some firms make extensive use of the numbers attached to each entry in the alphabetical section as a telegraphic code when cabling their agents or principals. Finally, we congratulate the editors on having, especially so far as the foundry industry is concerned, materially improved what was already an indispensable reference book to their trade.

Notes on Iron Foundry Practice.

At the December meeting of the Sheffield Section of the Institute of British Foundrymen, held at the Albany Hotel, Sheffield, Mr. Horace J. Young, F.I.C. (consulting metallurgist), of London, gave a talk on "Iron Foundry Practice," which was illustrated by many fine slides. Mr. Ambrose Firth presided over a large meeting.

MR. YOUNG said he had promised to give them a talk—a very different proposition from giving a previously-prepared Paper—and so that it should be as interesting and as straightforward as possible he had deliberately prepared nothing but was going to describe foundrywork as he had seen it in many foundries. As a consultant, he saw foundry work from the point of view of people who were in trouble, which was another aspect to that one obtained by visiting foundries not in difficulty or, at any rate, not admitting it. People in trouble and seeking advice were compelled to lay their cards on the table and, invariably, those cards were not those usually dealt.

One is told—and told *ad nauseam*—that the whole trouble is lack of remunerative orders. He believed the lack was an effect of the trouble and not the trouble itself. Many foundries did not deserve to get orders; some used expensive materials and turned out third-rate iron; others were working without knowledge of cost and making a loss; yet others were cutting prices, losing money and spoiling the market. As with the coal mines, it would be good—it will be necessary—that some foundries should shut down.

The scientific man must turn his thoughts to the business end of foundry work as well as to metallurgy. Instead, frequently, foundries were employing people who were business men instead of scientists, and were out to serve up imitation science to the disadvantage of everyone concerned. Moreover, it was often the case that those in charge of foundries were either commercially educated, or trained in machine shops, and had small knowledge of foundry matters. Losses attributed to bad trade were due sometimes to bad management. By bad management he did not mean culpable neglect but ignorant management.

Using High-Class Pig Iron.

In this country thousands of tons of "special" pig-irons were used by foundries. Irons for closing up the grain—irons for giving wonderful wear—irons for making perfect castings. Looking around, one could seldom see any results, but always the huge waste of money on irons which need not be used. Most foundries using them were totally incompetent to make the best of them. Only in high-class manufactures was expensive pig-iron justifiable, and then it must be done under the direction of a genuine metallurgist with long foundry experience. To give an ordinary chemist or foundrymen irons of this type was like putting a very delicate and intricate piece of mechanism in the hands of someone totally unfit to manipulate it.

Many foundries were using expensive fluxes; this applied to the brass trade as well as to the iron foundries. Such fluxes were totally useless, could be made for half the price they were sold at, and nobody with scientific knowledge of foundrywork could recommend or justify their use. So far as ordinary iron foundry practice went, they could take it that if limestone did not give the desired results no other flux would do so. Investigation of the claims made for these fluxes showed that they are entirely fictitious; one cupola-flux, he had in mind, was said to make the iron hotter. The deplorable part of it was that these things had a large sale, and were marketed under the name of "science."

The mixing of sand was an item about which little was really known but much was claimed. In many foundries sand was purchased and used in the "good old manner," and half the precautions and mixtures claimed exist solely in the minds of those claiming them. Sound knowledge on the sand question was needed, but, thus far, the main result of the work done appeared to be a number of peculiar methods of testing sands for properties which did not function in practice. Ordinary moulds were not porous to gases during that period when the getting away of the gases was vital, namely, immediately after pouring and before the metal forms a skin. That was undoubtedly true so far as grey iron foundry-work was concerned.

Wasters and Annual Metal Consumption.

Some people appeared to believe that a foundry was doing well if the number of rejects was low. He had seen foundries where the whole of the brains of the establishment were occupied in keeping down this figure, and in no few cases the figure, thus kept down, was wholly fictitious and misleading.

It would be well if foundries found out annually how much metal (pig-iron, steel and scrap) was melted to produce one ton of good castings. Few foundry managers had thought about any such figure, yet it was one of the main roots of success or failure to make profits.

The consumption of cupola-coke varies all over the foundries of this country. There could be large savings effected. He had done many years of research upon cupola control and could not write half a page of knowledge gained thereby. The fact was that the cupola, like any other furnace, required so much coke to burn so much air—and *vice versa;* keep that balance correct and there was very little difference anywhere, save in the coke consumption. This explains how it was that cupolas were being worked in ten thousand different ways and were all giving iron from which castings were being made.

For high-class work the simpler the cupola the better—here, success depends upon skilled scientific control, and could not be obtained without it. Indirect labour was an important item. Overdoing this class of labour invariably results in general slackness throughout the foundry.

Hundreds of foundries were spending little or nothing on brains—on foundry brains. These must be individuals trained, not in commerce nor in engineering, but in moulding metallurgy and foundry management. The commercially-trained brain may be necessary for managing the finances of a company but was hopeless when it came to a speciality like a foundry. He had seen several costing systems which were valueless, wholly because those making them did not understand that which the costing system was supposed to explain and to assist.

Mr. Young, proceeding to show a number of lantern slides, said that carbon was one of the mysteries of cast iron. In these days foundrymen and metallurgists had followed the example of the man-in-the-street regarding his politics, namely, everyone knew all about graphite and pearlite, though before the war they hardly knew the names. The truth was that both graphite and pearlite to-day were greater problems than ever. "The more we find out about them the less we are sure we know."

Curly, Bobbed and Shingled Graphite.

Recently there had been a Paper read in which there was a considerable talk about "curly" graphite. "The next example of scientific progress will be bobbed or shingled graphite. Place before anyone a hundred castings—made differently from different materials and by different processes—and there is not a man alive who could pass valuable judgment on them according to the curliness of the graphite. Let anyone try to make a casting, using modern mixtures, where the graphite was not curly, more or less, all over the casting." That "more or less" was the stumbling block and the metallurgist who showed his curly graphite in a pin-point of the metal of a large casting, was like a man demonstrating the properties of the earth by a snapshot of the Dead Sea.

The same applied to pearlite. Everyone to-day claims to make all-pearlitic iron and for no better reason than that they follow somebody's well-advertised system and have heard that all-pearlitic iron is desirable. Speaking as one who, with no less justification, could have made this claim thirteen or more years ago, he could tell them that it was the mere fringe of the subject—the popular-newspaper fringe.

The properties of an iron depended upon its complete composition and structure and how it was melted and cooled. Some low-carbon iron was very poor stuff; some so-called all-pearlitic iron was equally poor. An iron could not be valued by general statements about its curly graphite, its low carbon, its pearlite. If this nation was to come up to the level of certain continental nations it would be by pulling together and refraining from claims that we knew all about cast iron. Instead, we knew very little and our foundry trade was backward in the science of cast iron; so backward that we were unable to appreciate the vast funds of knowledge underlying some of the research of our foreign competitors.

Incorporation of Steel in Cupola Charges.

He would remind them that, before the war, few foundrymen knew that steel could be used without giving bad castings. The Americans came along and taught them how to do it, which was all to the good, but the deplorable result to-day was that many foundrymen and chemists using steel claimed to be making material with every desirable property. Actually, he was making, if he was doing it properly, a cheap and good iron, which he could have made years ago if he had tried intelligently or believed others who had tried and been successful. Using steel in the cupola, for certain work, was not metallurgy, it was common sense.

This talk was intended to point a moral. Before making progress it was necessary to realise where we stood: before we could realise that, it was essential to have sufficient real knowledge to find out. Our moulders were all right and could produce as intricate castings as those of any other nation—we could not blame the moulders. Few foundries paying adequately for good management and genuine science were having any trouble apart from post-war depression; the others were in serious difficulties. Obviously, good management meant genuine science because a good manager would have no other and knew it was better to have none at all than a cheap substitute. Given scientific management, scientific costing, scientific procedure, and a foundry would either make profits or know why it was not doing so; either apply the remedy or close down if the remedy was impracticable. A lot of money yet remained to be made by modern foundry practice.

Discussion.

THE PRESIDENT said they had listened to what was a most interesting talk. The question of profit or loss was really the question of the price they were getting for the castings. If they were making a casting in which there was considerable amount of risk they naturally expected to get a price which was commensurate. A great deal of the loss could be saved by having the runners of the proper size. With reference to temperature, if anyone could get up to 1,475 deg. C. he was doing well; he had not used pig-iron containing 80 per cent. of steel, it was something rather new to him, and was of opinion that such an iron would be very "sticky."

THE PRESIDENT said that as to the question of waste, their's worked out at 7½ per cent.

MR. YOUNG: What class of casting are you speaking of?

THE PRESIDENT: Heavy castings.

MR. YOUNG: In actual practice they have a loss of about 6 per cent. which leaves only 1½ for the speaker to play with. The question is how much metal do they use to produce one ton of casting.

THE PRESIDENT: If they were quoting for a job at a cutting price they would reckon what was the difference between the weight of metal and material which they put into the cupola and the weight which went over the scales. Runners, risers, etc., would go back as scrap.

MR. YOUNG said he knew a firm which was spending thousands of pounds in re-melting the metal which was never accounted for in their costing sheets.

Permeability of Moulding Sands.

MR. J. G. A. SKERL, speaking as one who had carried out research work on moulding sands,

crossed swords with Mr. Young when he denied the necessity for permeability. Whilst most of the gases present in the mould cavity undoubtedly escaped through the runner and risers, he would draw attention to the fact that it was the gases present in the sand itself, or produced from the material in the facing on casting which promoted the conditions for which sand permeability is desirable. In a green-sand, or any mould, there are about 30 per cent. of air spaces between the grains. For every 273 deg. C. rise in temperature air will expand to an amount equal to its own volume, exerting an increase of another atmosphere, so that at a casting temperature of 1,300 deg. C., a pressure of 5 atmospheres will be created in the sand from this cause alone. A green-sand mould, containing moisture usually of the order of 5 per cent., which on contact with hot metal will form steam, an ounce of water producing 1¼ cub. ft. of steam at 100 deg. C. This steam expands at the same rate as air, to exert an increase of pressure of one atmosphere for every 273 deg. C. rise in temperature. The gases evolved from coal dust and from the clay of the bond, will act in a similar manner, and it can be calculated that a pressure of at least 10 atmospheres is attained near the face of every green-sand mould. The speaker asked Mr. Young in which direction he thought the pressure was released, through the metal or through the sand? He also expressed the view that scientific brains of themselves were not always successful in a foundry, but only when combined with the practical experience or "art" only to be obtained by intimate contact with foundry work.

MR. STEELE said he was highly interested in what was said about sand not being porous. He had made dozens of moulds without a single vent in them. He granted that, although boxes had been machined, the gases escaped between the joints, but he had seen the whole area on top of the boxes one mass of flames, even when depth of top parts were 5 in. to 7 in. If sand was not porous, what caused these flames on top of box?

Replying to Mr. Skerl, MR. YOUNG stated that the quotation of the laws of Charles and Boyle did not appear to help them; moreover, those laws could not be expected to operate within a mould in the elementary manner suggested by Mr. Skerl. He thought that the gas pressure within an ordinary sand mould was released mainly through the apertures in that mould and not through the pores of the sand. In high-temperature work, where the pressures were greater, additional venting had been found to be the sovereign remedy.

Mr. Skerl went astray if he thought that he (Mr. Young) believed that scientists were the only people useful in foundry practice. Because a man had been trained in science it did not follow that he acquired brains; probably, he finished with precisely that amount with which he started. This might be an explanation of the failures scientists had made occasionally in practical matters. A clever moulder or foreman was as brainy as a clever chemist; more so than a less clever one. Moulders and metallurgists were necessary equally to our foundry industry, but both must possess grey matter.

In reply to Mr. Steele, MR. YOUNG stated that he had never seen mould gases forced through 5 in. or 7 in. of sand and a mass of flame over it. Perhaps the tops of the moulds, mentioned by Mr. Steele, were prepared with ashes or some other artificial venting. That he had seen many moulds poured and never observed what Mr. Steele described appeared to suggest that, in the case quoted by Mr. Steele, there was something different to account for it.

Temperature of Cupola Metal.

Answering the President, MR. YOUNG said that 1,475 deg. C. was the highest temperature he had observed at the tap-hole of a cupola. Temperatures of this order, 1,400 deg. C. and upwards, were essential to high-class practice where metal having as little as 0.5 per cent. of silicon had to be poured into intricate moulds. It was a question of cupola practice and scientific control.

Pig-irons containing from 60 up to almost 100 per cent. of steel were popular in this country, and very good if used scientifically; very bad if not. His statement was that the ordinary foundry had no knowledge how to obtain benefits from the use of expensive irons or fluxes, and were wasting on such things money which could be expended profitably on the genuine scientific help they needed so much.

The President's remark that their waste was 7½ per cent. was not the point which had been raised. The question was how much metal did he melt in order to produce one ton of good castings. For instance, if one melted 100 tons of metal to produce one ton of good castings it would obviously be an expensive proposition, because there would be 99 tons to be carted to the cupola to be melted, to be taken to the casting, to be provided for in the mould or its surroundings, to be removed from the foundry, and to be taken back to the cupolas or the scrap heap. Incidentally, about 6 per cent. of it would be lost during melting.

The light of applied science thrown on the methods of management and commerce often revealed important financial points which hitherto had escaped observation. As with everything else, it was a matter for co-operation. Efficient moulders, managers, metallurgists and accountants were all necessary to a foundry, each knowing something that the others did not. The trouble was that sometimes one of them thought he was the only one who mattered, or sometimes one of them was done without.

MR. F. A. MELMOTH and MR. J. R. HYDE also contributed to the discussion, at the end of which a very hearty vote of thanks was accorded Mr. Young.

Notes on Heat and Acid Resisting Pig-Irons.

BY TUDIS.

These notes have been compiled principally from practical working as foundry foreman from 1926 to 1928.

It should first be ascertained under what conditions the castings are to be treated and the subsequent working methods. A distinction must be made between castings that can be used without machining and castings which have to be machined.

Castings Which Need Not be Machined.

From the point of view of maximum heat resistance a white fracture is to be preferred. It is vital, however, for the fracture to be obtained by the use of metal of a balanced composition, low in total carbon, silicon and phosphorus. A white fracture obtained by the use of common iron abnormally high in sulphur, produced when the blast furnace is working irregularly, is not satisfactory for heat resistance. The castings should be so designed as to leave no sharp corners or too abrupt change of thickness, or it becomes liable to crack in the process of heating or alternate heating and cooling. This heating is, in effect, an annealing process in which the fracture changes from white to grey, and failing proper attention to design the casting will crack or fly shortly after being put to work.

Castings Which Have to be Machined.

The fracture should be grey, but as close as possible, in fact, the thinnest portion of the casting should almost verge on the mottled. Remember that the harder it is to machine, the better the service it will give.

The composition of the metal is important, and it is necessary to know accurately the analysis of the various irons, etc., used in the mixture. A comparatively small variation in phosphorus for instance will greatly affect the life of the castings. The actual analysis of a casting which gave good results is as follows:—Total carbon, 3.06; silicon, 1.00; manganese, 0.48; sulphur, 0.064; and phosphorus, 0.19 per cent.

The writer has been concerned with a number of tests with different mixtures during the past few years, and the best results have been associated with compositions approximating the above. It should be noted, however, that for thin castings the silicon may have to be raised up to 1.3 per cent. With regard to manganese, it is probably preferable for this to be raised to 0.8 or even 1.0 per cent.

The mixture used to obtain the analysis given above was as follows:—

4½ cwts. West Coast hematite iron (silicon 1.5 per cent.).

4¼ cwts. South Staffs. refined iron (silicon 1.0 per cent.).

1 cwt. its own scrap.

¼ cwt. steel scrap, not less than ½ in. thick.

For the first charge the mixture was slightly adjusted. For certain purposes, such as moulds for aluminium melting, soda and cyanide pots, and other special work, it is advisable to work to a lower phosphorus content. This was done by substituting a refined iron with 0.06 per cent. phosphorus in place of the above, which contained 0.40 per cent. phosphorus.

It has been found by experience that the following practical points, if carried out, will facilitate sound castings.

(1) The mould should be stove heated up to 300 deg. C.; (2) gates and runners should be double the ordinary size; (3) no great heads and no feeding are required; (4) use swish runners if possible; (5) use a clean cupola and keep metal well separated from other mixtures run on same day; (6) the first charge should be small, and the first cwt. or so run on the floor; (7) the metal should be run very hot, and when entering the mould should be just off the boil; (8) well mix the cupola metal in a large ladle; and (9) a wedge test should be moulded, heated and cast under the same conditions, to test the fracture in the various thicknesses of metal. The wedge would be about 6 in. wide and grooved down the centre to facilitate a clear full-length break. It can be made with short parallel steps of varying thicknesses to correspond with the thin sections in the castings.

In conclusion, it is most important to note that the best material can be completely ruined by cracking or splitting if, when first being put to use, the fire is not gently and slowly brought up.

The Spanish Foundry Congress.

Details are now available of this interesting event, which is to last from Tuesday, April 10, to Friday, April 27. The cost is estimated at roughly 4,000 French francs, plus the cost of the journey to Barcelona and from Bilbao or San Sebastian home again. The details can be obtained on application to the head office of Messrs. Thos. Cook & Son, Limited, Piccadilly, London, W. The congress opens on April 11, and technical sessions are to be held in the morning of this day, the two following mornings and the Saturday afternoon. The papers are to be printed in French and Spanish. The rest of this period is to be devoted to works visits, and amongst those scheduled are La Maquinsta Terrestre y Maritime; the Hispano-Suiza Motor factory; Ameter factory; the Gran Foundry; May y Baga Foundry; the Escoria Foundry; the Sert Works; and the local technical school. The visitors will leave Barcelona on Sunday, April 15, and follow the following itinerary: Sunday, Valencia; Monday, visit to the blast furnaces at Segunta; Tuesday, Seville; Wednesday, visit to Arsenal; Thursday, Cordova, and visit to the Electro-Macanica Works; Friday, visit to the Electro-Metallical Company's works at Penarroya; Saturday, Madrid; Sunday, April 22, reception by the local committee; Monday, Toledo, where a small arms factory will be inspected; Tuesday, visit to the railway shops; Wednesday, Bilbao; Thursday, visit to the Eibar small arms factory; Saturday, San Sebastian, where the tour ends.

THE PARTNERSHIP heretofore subsisting between Messrs. D. H. Barnard, J. H. Barnard, A. H Barnard, M. H. Barnard, W. H. Barnard, L. H. Barnard, H. B. Barnard, E. A. Barnard, and G. M. Barnard, carrying on business as metal merchants, at 149, Leadenhall Street, London, E.C., under the style of Barnard Bros. & Company, has been dissolved, so far as concerns Mr. E. A. Barnard.

The Manufacture of Steel-Mix Grey-Cast Irons, with Special Reference to their Treatment in the Foundry.

By Arthur Smith, M.A.

During the last ten or twenty years a great deal of attention has been given to the production of high duty cast irons and the improvement of grey-iron castings in general. There exists in the engineering trade an ever-increasing demand for grey-iron castings capable of standing up to very severe service conditions, not only in cases where the main object is increased strength and durability under ordinary conditions of moderate temperatures and pressures, but also where conditions are such that increased resistance to heat, freedom from growth, perfect soundness under exceedingly high pressures, maintenance of strength at high temperatures and similar qualities are essential to the success of the structure or machine built up from such castings.

Most of these conditions can be fulfilled by using high percentage steel-mix castings containing suitable proportions of carbon, silicon, manganese, sulphur, and phosphorus. Unfortunately, freedom from growth and the greatest resistance to heat can only be obtained by the adoption of irons not only containing the eutectic ratio of combined carbon throughout all parts of the casting but that carbide must be stabilised either by controlling the silicon content so as to be considerably under 1 per cent. or perhaps by the addition of suitable amounts of chromium to comparatively low silicon irons. Such grey irons can at present only be made by such processes as the hot mould process as carried out under the Lanz patents. However, by the adoption of suitable mixtures and correct melting technique, it is possible to make with perfect regularity 30 to 60 per cent. steel-mix grey-cast irons, which will be almost entirely pearlitic in structure, be readily machineable and yet possess vastly superior properties to grey irons made from pig-irons alone or pig-irons mixed with cast-iron scrap.

Classification of "Semi-Steel Cast Iron."

Steel-mix irons may be roughly divided into two distinct classes, namely:—(1) With total carbon content 2.8 per cent. or less to 3.2 per cent., and (2) with total carbon over 3.2 per cent., and, in the writer's opinion, the term high-duty steel-mix grey-cast iron can only be applied to the first class containing moderately low total-carbon.

This latter class of metal is quite unnecessary for the ordinary run of general castings, and is in fact quite unsuitable. Steel may be added to mixtures merely with the sole aim and object of diluting the silicon and phosphorus present in the low-grade pig-irons or scrap, the resultant iron, provided the proportions of phosphorus, silicon and manganese are suitably regulated to the section and mass of the castings being produced, being much stronger and less brittle than the very high-phosphorus, high-silicon irons which would result from using such low-grade materials alone. Steel scrap thus added to the cupola in amounts reasonably large to be effective undoubtedly helps to reduce the size of the graphite particles or graphite voids, but the total carbon-content in such irons will be comparatively high unless the cupola practice is so controlled as to ensure total carbon under 3.2 per cent. For ordinary castings this is all to the good, as the other steel-mix irons containing less silicon and less total-carbon show a greater diminution of volume on changing from the liquid to the solid state. For really high duty irons, however, one must look to the lower carbon cupola-melted steel-mix irons, and it is with these that the writer intends to deal.

Various hypotheses have been put forward from time to time with regard to the mechanism of the absorption of carbon by steel in the passing through the cupola, and from a purely metallurgical aspect these are very interesting. It is generally recognised that steel does very readily reduce the total-carbon content in any mixture because the steel readily absorbs about 3 per cent. carbon, but by using heavy percentages of steel in conjunction with comparatively low total-carbon pig-irons, it is possible to produce regularly cupola-melted cast iron with total-carbon in the region of 2.9 to 3.0 per cent.

Graphite in Semi-Steel Cast Iron.

One very interesting theory put forward recently by various authorities is that the carbon in the form of graphite in pig-irons and cast irons can pass through the melting zone of a cupola without being completely dissolved, and that this undissolved graphite forms centres round which additional graphite is later thrown out of solution, the ultimate size of the flakes depending on the amount of original graphite remaining out of solution when passing through the melting zone.

Most foundrymen and metallurgists now agree that the use of steel scrap does produce definitely smaller graphite, and the lower the total-carbon content, all other things being equal, the greater will be this graphite-refining influence, but the practical foundrymen are less concerned with the theory of such processes as they are with the practical details of making such castings.

Melting Furnaces.

Correct cupola practice is the first essential towards success, because in most foundries it is still necessary to melt such mixtures in a furnace of this type. In foundries of the future other methods of melting and perhaps superheating mixtures of grey-cast iron and steel scrap will no doubt be available, but up to the present, no furnace has yet proved itself capable of replacing this simple and cheap method of melting. Provided reasonable care is taken it is always possible, when using mixtures containing 30 to 60 per cent. steel scrap in the charge mixed with low or moderately low phosphorus irons, to obtain metal at the cupola spout at a temperature of not less than 1,400 deg. C.

Cupola Design.

The design of the cupola should be as simple as possible. Simplicity of design means a reduction of the unavoidable variables to a minimum. The writer advocates strongly a perfectly parallel lining, the tuyeres being arranged in one row and the ratio of the total working tuyere area to the cupola area at the melting zone should be as near 1:6 as possible. The tuyeres should be separately-controlled, and each should be capable of being entirely shut off. This obviates the poking of tuyeres to a very large extent, a practice which often becomes a habit with furnacemen. If each tuyere in rotation be shut off for a few minutes at a time, then the so-called "black" tuyere opening will be unknown. The cupola belt should be constructed so as to offer the least possible resistance to the blast. In a badly-designed air-belt frictional losses may be heavy. An excellent type of belt which is gradually gaining favour in the foundry world is the circular section belt in which the air is led in at a tangent, and the individual tuyere openings take the form of circular section pipes from the bottom of the main circular wind belt, as shown in Fig. 1.

The air blast should preferably be supplied by a direct-coupled fan, which must be provided with a wide latitude of speed regulation and the air-pipe leading to the cupola belt as short as possible and straight, or, if a bend cannot be avoided, it should be in the form of a gradual curve. This air-pipe should be tapered from the fan outlet, increasing in diameter to the point where it connects up with the tangential inlet pipe to the cupola belt. The height of the cupola from the centre of the tuyeres to the charging sill should be as high as possible. The capacity of the well should be such that the molten metal resulting from a definite number of charges can be tapped from the cupola at each tap. The importance of this will be explained later.

Charging Practice.

The charging of the cupola may be carried out either by any of the well-known mechanical devices for loading on the ground level and subsequent tipping of the charge into the cupola or by direct handling of the materials piece by piece, that is to say, complete charging by hand. If mechanical charging is adopted, then provision must be made either in the design of the tipping bucket or the shute into the furnace to ensure perfectly even distribution of the charge.

Composition Sought.

The composition to be aimed at should first be decided on, and the mixture made up accordingly. The following may be useful for guidance:—

Total Carbon.—From 2.9 to 3.2 per cent.

Silicon must be regulated to suit the mass and section of the castings being made. For heavy lumpy castings 1.0 to 1.3 per cent.; for medium castings, 1.3 to 1.7 per cent.; for medium light castings, 1.7 to 2.2 per cent.; and for lightest castings, 2.2 to 2.8 per cent. are suggested.

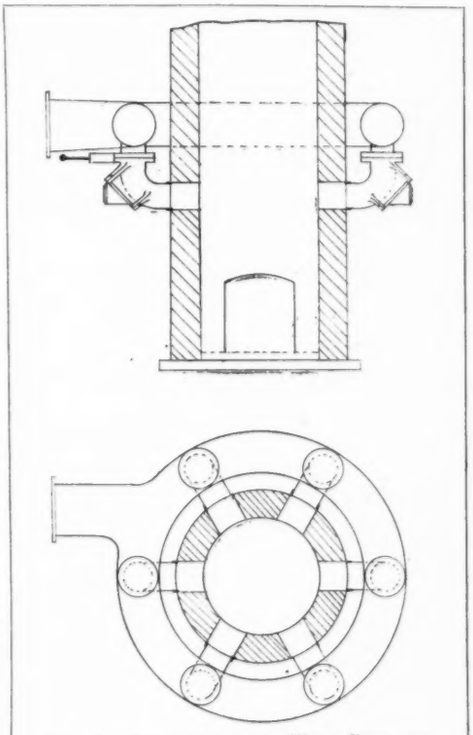

FIG. 1.—ARRANGEMENT OF WIND BELT AND TUYERES.

Phosphorus.—For high-duty castings this element should always be kept low, and certainly not over 0.5 per cent. It will be found that 0.2 to 0.4 per cent. is a convenient limit range to aim at where maximum strength and soundness is sought, and as such irons are poured at high temperatures the use of such low percentages of phosphorus do not introduce any difficulties in the running of comparatively thin castings.

Sulphur.—This element cannot be controlled apart from keeping the initial percentage charged as low as possible and using coke with low sulphur-content, but it is often very false economy to pay higher prices for extremely low sulphur materials. However, in high-percentage steel-mix irons sulphur up to 0.25 per cent. will not cause any trouble provided it is adequately balanced by a sufficiency of manganese. In the writer's experience 40 to 60 per cent. steel-mixture irons will often show a large pick-up of sulphur, but provided the metal is correct in all other respects and poured at a sufficiently high temperature no

trouble will be experienced. In fact, it will be found later that high sulphur may be beneficial in castings for certain uses.

Manganese.—Manganese should be kept reasonably high; 0.8 to 1.2 per cent. will be found to be a very safe range, the lower limit being aimed at in the higher-silicon irons and the higher limit with the lower-silicon irons.

Choosing Steel Scrap.

The type of steel scrap to be used is very important. The chemical composition of the steel matters little, as small amounts of alloy constituents, such as nickel and chromium, will improve the resulting cast iron. Of course, it would be neither advisable nor economical to charge scrap containing considerable amounts of alloy constituents. What does matter is to have the steel in suitable masses. Very light steel scrap has been proved to cause trouble, probably for more than one reason. Practical tests have shown that much more reliability can be had with medium-heavy sections of steel scrap, such as heavy rail-end scraps, fish plates, forge-shop scrap, billet-ends, and, where available, headers and similar spare metal from steel castings. With light steel-scrap the same amount of superheat is not obtained, and the result is sluggish, and probably highly oxidised metal which runs dead and causes blowholes on the top surfaces of castings. A plentiful supply of cheap steel-scrap suitable for the purpose is usually readily obtainable. The remainder of the mixture may be made up from low or medium phosphorus pig-irons, the silicon content being controlled by the addition of carefully-regulated percentages of high-silicon hematite irons. Such irons containing 7 to 10 per cent. silicon with less than 0.10 per cent. phosphorus are obtainable at a reasonable cost, and their use, besides being economically sound, makes for greater certainty in obtaining the desired silicon content in the final metal than is the case with high-silicon ferro-silicon.

How to Add Manganese.

Manganese is added in the first place in the pig-irons, as it is cheaper to buy pig-iron for mixing purposes which is high in manganese, because all other things being equal, high-manganese pig-irons are usually sold at the same price as low-manganese pig-irons. If extra manganese is essential to the final composition, then it should be added in the form of massive ferro-manganese direct to the cupola charge. It is possible to purchase ferro-manganese in irregular-shaped lumps weighing 10 to 50 lbs. each, quite free from all smalls, and these lumps may be carefully broken to give the desired weights per charge.

Of course, it goes without saying that all metals, fuel and flux, must be accurately weighed. The charges should be small, and all the metals charged in a single bucket or skip if mechanical charging is resorted to. The pig-iron should be broken to regular size, the mass of individual pieces depending on the size of the cupola.

The height of the coke bed above the centre line of the tuyères is important. Quick melting in order to get hot metal from the first charges is essential, and this can best be had from a high coke bed, a height of 4 ft. above the tuyères being quite usual. Of course, the higher the bed the greater the carbon pick-up, but as only moderately low total-carbon is being aimed at, quick melting will keep the carbon down to reasonable limits if low-carbon metals have been charged. Where lower carbon is aimed at, a low coke bed will have to be resorted to, but then more difficulty is experienced in maintaining the tapping temperature.

Tapping Based on Charge Weight.

The size of the charges should be arranged so that the well holds two or three at a time after melting, and the metal should always be tapped in quantities representing the capacity of the well; that is to say, if the charge is 800 lbs., it will be convenient to tap rather less than 2,400 lbs. of metal at a time, representing approximately three charges. The size of the charge will also depend on the melting capacity of the cupola, but it is well to bear in mind the fact that as far as steel-mix irons are concerned, small charges will give much greater consistency in the final composition than will large charges. A good cupolaman will soon become skilful at accurately gauging the height of the molten metal in the well necessary to give the required amount at a single tap. This regulation of the molten metal in quantities representing multiples of the metal charges is especially important when pouring large numbers of small castings in this class of metal. The metal is best handled by quickly transporting the bulk-ladle to a point in the shop most suitably situated for distribution in small shanks or hand ladles for very small moulds. It is essential that this class of metal be handled quickly if the best results are to be had. All ladles should be made very hot for the reception of the first metal in any individual instance.

When a high percentage of steel scrap is used the loss of silicon and manganese is usually greater than in ordinary grey-iron mixtures. The loss in manganese may run as high as 35 to 40 per cent., and it is seldom less than 25 per cent. However, melting conditions can be so standardised that the percentage loss is kept almost constant.

The volume of air entering the cupola should be measured by a pitot tube instrument, and, once a constant has been reached, it should be rigidly adhered to, and the pressure should be kept low, 12 ozs. being a good average figure.

Moulding methods differ little from the ordinary, except that facing sands and castings may with advantage be altered to withstand the higher temperature metal. All castings without exception must be poured as hot as ever possible if success is to be assured. In the case of dry-sand moulds and loam moulds, special care must be taken to get the right mixture of plumbago and blacking and other castings so that the castings will strip well. As with ordinary grey-irons, light and medium weight castings may be cast in green-sand moulds.

Co-ordinated Effort Necessary to Success.

The process by which all castings are produced in sand moulds is dependent on the moulder's art in providing a sound mould and the metallurgist's art in providing molten metal of correct composition, temperature and viscosity, but unless there exists complete co-ordination between the two, a high percentage of failures is almost certain. This co-ordination is necessary in order that the mould may be filled with molten metal in the best possible way as regards rate of filling, initial distribution of the metal, etc., and that the metal, once the mould has been filled, shall be provided with the optimum conditions in regard to general speed of cooling, equalisation or differentiation of cooling in the various parts of the mass, as well as suitable provision of molten metal to make up for internal shrinkage up to solidification point and correct conditions of cooling.

In other words, the founder and the metallurgist must combine and co-ordinate their technical knowledge not only in the provision of suitable raw materials or mixtures of raw and prepared materials for the mould, but in arriving at the size, shape, and distribution of runners, risers and feeders, as well as the mass and distribution of chills and denseners (if any) in each individual casting or type of casting to be produced. The writer would state, without fear of contradiction, that in the case of high-duty engineering castings for retaining or containing liquids and gases under high pressures being produced in British foundries to-day, more than 75 per cent. of the faulty castings are due entirely to lack of attention to the points enumerated above as distinct from failures due to all other causes, including those directly traceable to faulty moulding, faulty coremaking, errors in assembling, venting, etc., as well as failures due to the use of poor moulding materials, unsuitable metal, etc. Although this state of affairs is true of all classes of iron castings, it is essentially true in the case of high-percentage steel-mix grey-cast irons.

Rod Feeding Not Advocated.

The practice of rod feeding should be abolished in all castings required to withstand high pressures, and it will be found that in the case of steel-mix irons the volume of feeding headers must be increased in some cases up to a maximum of 25 per cent. of the total weight of the casting, but, of course, the shape of a feeding header in any particular casting may be much more important than its actual volume or mass. The best plan is to ensure (with or without the use of denseners in the case of castings with widely differing thicknesses of section) that the header will have completely done its work of supplying the necessary molten metal to all parts of the casting proper before it, in turn, becomes solid. In the case of pressure castings for repetition work which are machine moulded it is usually possible so to embody the runners, risers and feeders in the pattern, that the method of production will be fool proof and unalterable, provided the metal used is within the correct limits of composition, temperature and viscosity at the precise moment it enters the mould.

By strict attention to all the details of foundry practice mentioned above perfectly sound high percentage steel-mix grey-iron castings can be produced day after day and year after year, and the castings can be relied on to possess qualities vastly superior to ordinary grey-iron castings, as a perusal of the physical properties of typical examples will prove.

Table I.—*Physical Properties of Steel-Mix Grey-Cast Irons.*

Cast No.	Per cent. steel in mixture.	Composition. Total carbon.	Si.	S.	P.	M.	Ni.	Cast size of test bar. Ins.	Tensile strength. Tons/sq. in.	Transverse 12 in. centres. Lbs.	Deflection. Ins.	Brinell hardness.	Remarks.
S 62	50	3.12	1.73	0.14	0.28	0.92	—	1½ (sq.)	18.3	—	—	—	—
								1 (sq.)	—	3,880	0.16	207	—
S 45	35	3.27	1.67	0.13	0.33	1.12	—	1 (sq.)	17.3	3,350	0.12	228	—
S183	45	3.04	2.24	0.11	0.47	0.79	—	1 (sq.)	18.0	3,600	0.13	228	—
S 96	40	2.92	1.97	0.14	0.24	0.87	—	2 (diam.)	17.8	—	—	—	—
								1 (sq.)	—	3,900	0.12	217	—
S 95	40	2.90	2.19	0.16	0.31	0.86	—	1½ (diam.)	18.4	—	—	—	—
								1 (sq.)	—	4,000	0.11	228	—
S181	45	3.00	1.53	0.17	0.26	0.85	—	1 (sq.)	18.4	3,800	0.09	207	—
S204	45	3.06	1.66	0.18	0.35	0.87	—	2 (diam.)	17.1	—	—	—	—
								1 (sq.)	—	3,850	0.14	207	—
S140	40	3.04	1.80	0.21	0.26	0.94	—	1 (sq.)	18.2	3,650	0.13	217	—
S 24	60	3.02	3.11	0.13	0.24	0.93	—	⅝ (diam.)	18.6	—	—	207	For extremely light castings.
S194	45	3.08	1.02	0.18	0.30	0.90	0.62	2 (diam.)	18.4	—	—	228	Machineability of castings excellent.
N278	45	3.04	1.49	0.14	0.25	0.81	0.52	1 (diam.)	20.1	2,400	0.14	217	Machineability excellent.
N279	45	3.00	1.36	0.14	0.26	0.89	0.53	1 (diam.)	21.0	2,800	0.16	217	Do.
S180	45	3.08	1.35	0.16	0.27	0.84	—	1 (diam.)	22.4	2,300	0.08	248	Machineability inferior, but fracture quite grey.
S164	45	3.10	1.28	0.17	0.19	0.78	—	1 (diam.)	21.8	—	—	248	Same as S180.
N280	45	3.14	1.37	0.16	0.22	0.76	0.47	1 (diam.)	19.8	2,600	0.15	207	Machineability excellent.

Table I gives details of the composition and physical properties of numerous representative casts of this class of cast iron, the percentage of steel scrap used being stated in each case. In addition a few examples are given where nickel has been added with the idea of maintaining the strength of the cast iron and at the same time improving the machineability.

Table II gives a limited comparison of the influence of thickness and mass casting sections on the physical properties of these irons and also a comparison of two grey irons comparatively high in total carbon.

TABLE II.—*Comparative Physical Properties of Steel-Mix and other Grey-Cast Irons, with Special Reference to Casting Size of Test-Bars.*

Cast No.	Per cent. steel in mixture.	Casting size, diam. in ins.	Test-piece cut from centre or edge of test bar.	Tensile strength. Tons per sq. in.	Brinell hardness.	Shear. Tons per sq. in.	Izod Impact test.	Composition of metal. T.C.	Si.	S.	P.	Mn.	Ni.	Remarks.
A1076	None	1	Centre	14.5	207	12.3	10	3.62	1.85	0.13	0.49	0.87	—	All test bars were cast in green sand moulds from approximately the middle portion of the same ladle of metal.
		2	Centre	10.5	170	12.3	10							
		3	Centre	9.2	163	10.6	9							
		3	Edge	12.3	170	11.4	12							
		4	Centre	8.4	158	9.8	8							
		4	Edge	11.2	170	11.2	10							
S193	30	1	Centre	17.4	217	12.8	13	3.06	1.96	0.14	0.45	0.78	—	Do.
		2	Centre	16.8	207	12.3	11							
		3	Centre	15.2	187	12.1	11							
		3	Edge	16.9	196	12.4	12							
		4	Centre	14.0	170	11.2	10							
		4	Edge	15.7	196	11.7	12							
A1085	None	1	Centre	16.8	248	12.8	10	3.58	1.32	0.08	0.36	0.84	—	Do.
		2	Centre	15.2	217	12.4	9							
		3	Centre	10.8	207	11.5	10							
		3	Edge	14.2	217	11.7	8							
		4	Centre	8.9	187	10.4	10							
		4	Edge	13.4	207	11.5	9							
N199	45	1	Centre	20.5	228	16.3	15	3.00	1.30	0.18	0.47	0.86	0.61	Do.
		2	Centre	17.8	207	14.7	12							
		3	Centre	16.1	187	14.5	16							
		3	Edge	17.2	207	14.8	15							
		4	Centre	14.9	187	12.8	12							
		4	Edge	17.3	196	13.6	10							
S137	None	5½	Centre	12.4	163	—	—	3.05	1.66	0.16	0.30	0.79	—	Green sand mould.
		5½	Edge	14.8	179	—	—							
C538	45	5½	Centre	7.8	137	—	—	3.50	1.71	0.09	0.92	0.53	—	Do.
		5½	Edge	11.2	170	—	—							

It will be seen that the tensile strengths are good and remain reasonably high when taken from bars cast considerably thicker than the usual 1 in. square or 1⅛ in. round. With moderately low silicon, as in casts S180 and S164, really high tensile-figures are obtained with small section bars, but this is at the expense of machineability. It is interesting to note that nickel additions to similar mixtures, while not materially reducing the tensile strength, greatly improves the machineability of the irons. The strength of high-percentage steel-mix irons appears to be due to the fact that the composition can be controlled to give an almost entirely pearlitic ground-mass, which pearlite is more or less completely sorbitised in the smaller section castings with nickel additions. The graphite flakes or voids do not tend to increase in size to the same extent as is the case in straight grey cast irons, but remain comparatively small and curly right up to the centre. Consequently the difference in tensile strength between test-bars cut from the edge of a section and from the centre of the same section is not so great. This is clearly seen from the results set out in Table II, which results are typical of many trials carried out on the same principle, that is, each series being cast in green-sand moulds from the same ladle of metal. Fig. 2 shows the location of the edge and centre pieces in any particular test-bar casting. The length of the castings was kept constant at 18 in. This drop in tensile strength of cast iron cast from the same metal into castings of different mass, all other conditions being constant, is, of course, a very well-known elementary phenomenon, but in the writer's opinion it is one which has not been sufficiently thoroughly explored by foundrymen and metallurgists. The low silicon (under 1 per cent.) moderately low carbon types of cast iron, as made by the Lanz process, as far as the writer knows, show the least difference of tensile strength from the edge of a large casting to the centre, but the results obtained from the cheaper high-duty cast-iron examples, such as casts N199 and S137, are very promising, especially from S137, when one considers the casting size of the test bar and the silicon content, which is admittedly too high.

Resistance to shock or impact is a property of cast irons which it is difficult to measure satisfactorily, and an attempt has been made in the present series of tests to use a modified Izod impact test in an attempt to get away from the usual repeated impact and tests where the size of the test piece is small. The dimensions of the test piece used are as shown in Fig. 3. The results are inconclusive, but would lead one to suspect that resistance to impact does not follow tensile strength. It is interesting to note in passing that similar tests have been carried out on Lanz Perlit irons, and figures varying from 15 up to 24 ft. lbs. have been obtained. Similarly double-shear tests, although following the tensile results in a general way, do not appear to show such a steep gradient from edge to centre in the heavier bars. The tests are given for what they are worth, but must be regarded with caution until further work has been accomplished.

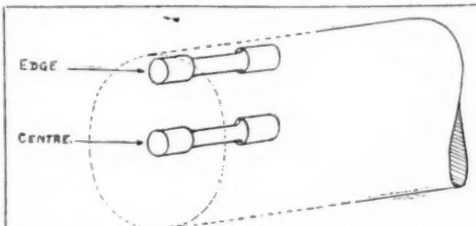

FIG. 2.—POSITION OF TEST PIECES CUT.

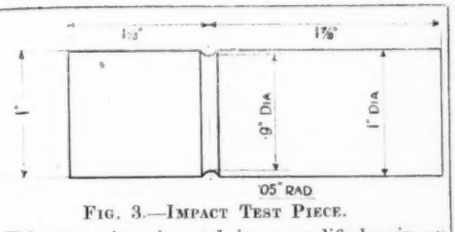

FIG. 3.—IMPACT TEST PIECE.

This test piece is used in a modified grip on the standard Izod machine, with standard striking distance and velocity.

Of the remaining physical properties of this particular type of steel-mix cast iron, which have yet to be more fully investigated, the most important are resistance to wear or abrasion, resistance to heat, and freedom from growth. As far as can be judged at present the low silicon grey cast irons, *i.e.*, with silicon well under 1 per cent., are likely to hold their own against all comers as far as freedom from growth and resistance to heat are concerned. The steel-mix irons with silicon between 1 per cent. and 1.3 per cent. appear to come next in order of merit.

It is very difficult to get definite data of resistance to wear of any class of cast iron as so many variables come into operation. The percentage loss of weight of one piece of metal when rubbing against another is very different when frictional surfaces are lubricated and when they are not, even if all other conditions are kept constant. At the present time a considerable amount of research is being carried out in this and other countries on the wearability of cast irons, but the author's work is at present incomplete. In Germany Otto H. Lehmann * has shown that there is little relationship between Brinell hardness and abrasion by rubbing friction, and after testing many cast irons against steel, soft cast irons and hard cast irons, he has arrived at the definite conclusion that in all three cases resistance against wear increases with increasing pearlitic content, and that abrading castings of purely pearlitic constitution show the lowest wear. As the cast irons described in this article are almost entirely pearlitic in structure one would expect their wearing qualities to be good. In actual practice gear blanks made from this class of metal stand up well to severe conditions of service. An interesting point in regard to the question of wear is that steel-mix irons high in sulphur and manganese usually possess a microstructure having a good distribution of the manganese sulphide, the shape of the particles being almost analogous to the diamond structure in white metals or the structures met with in phosphor bronze, that is, hard particles in a softer matrix. It may be that the manganese sulphide particles are helpful in this way, but it is essentially a point for exhaustive research. In the author's opinion much work which has been carried out on the resistance of cast irons to abrasion has not covered a sufficiently wide field.

In conclusion the writer would like to attract the foundryman's attention to these high-duty cast irons made from really cheap materials. Nothing new is claimed, but the ingredients of the mixtures used are really cheap and the results obtained are good. The use of large percentages of steel scrap and moderately cheap pig-irons is a much more economically sound proposition than is the use of large quantities of expensive pig-irons. Even the addition of small quantities of nickel in the lower-silicon irons to increase machineability can be carried out economically when the use of expensive refined irons is taboo. It is only by mutually striving to produce really easily machineable high-duty grey-iron castings by the most economical methods and employing the cheapest raw materials that the foundryman and the metallurgist can help to foster the prosperity of that part of the grey-iron foundry trade engaged in the production of high-duty engineering and machinery castings.

* Lehmann, O.H.: Abnutzung des Gusseisens gleitender Reibung, *Giess.-Zg.* 8 597ff.

Corrosion of Metals.

At a meeting of the London Local Section of the Institute of Metals, held on January 12, Dr. G. D. Bengough, of the Royal School of Mines, South Kensington, gave an interesting lecture on "Corrosion." The Chairman (Mr. A. H. Mundey) announced that Mr. S. W. Smith, D.Sc., A.R.S.M., F.I.C., who was to have given a Paper that evening, was indisposed and that Dr. Bengough had very kindly stepped in to fill the breach.

CORROSION WITH SPECIAL REFERENCE TO STANDARD TESTS.

Dr. Bengough pointed out that the search for standard tests for corrosion had become of considerable interest and importance to industrialists, not only in this country, but also in America; in fact, America had probably done more work on those lines than had been done in this country. There were many differences of opinion regarding the kind of test which should be sought, and there were certain difficulties involved in deciding upon a test and in the interpretation of that test when used.

If it was to be of industrial use, a standard test must present at least four characteristics. *Firstly*, it should be an acceleration test; for instance, it was useless devising a test which would take three years to show whether or not a batch of metal was up to standard; *secondly*, a standard test should be easily reproducible in two different laboratories. That reproducibility of a corrosion test was a question which presented special difficulties and had been one of the "snags" in the Americans' attempt to find a standard test; *thirdly*, the test should be sufficiently simple to form part of an ordinary works laboratory's routine; and *lastly*, a standard test should be readily interpretable in terms of the conditions of the practice.

All these requirements were very difficult to meet and could only be arrived at (if at all) by very careful investigations and by a more ample knowledge of corrosion phenomena than at present existed. One of the main difficulties was that a great variety of standard tests would be required.

Theory indicated that the rate of corrosion of a metal depended upon a very large number of different factors. Some referred to the metal itself and some to the conditions external to the metal.

Factors Relating to Corrosion.

Relative to the Metal.—(1) The electrical properties, particularly the electrode potential; (2) the state of aggregation; (3) the presence of internal stresses; (4) over-voltage; (5) the nature and concentration of impurities in solid solution; (6) the nature, amount and distribution of separate phases; and (7) the chemical reactivity.

External to the Metal.—(1) The temperature; (2) the pressure of oxygen; (3) the hydrogen in concentration; (4) the rate and distribution of oxygen supply; (5) the nature and distribution of corrosion products; (6) the conductivity of the liquid; (7) the metal in concentration; and (8) the specific nature of the anion.

If a pure metal was being considered, Nos. 1 and 2 relating to the metal were the important factors to consider. In the case of a fully-annealed metal the rate of corrosion would depend, mainly on Nos. 1 to 8 factors external to the metal. In order to get strictly reproducible results all these factors should theoretically be kept constant and this would be difficult to effect. Under certain circumstances, however, it was not essential to keep complete control over all these factors.

It might happen that under certain conditions one of these factors became so important that there could be considerable variation in all the others without very much effect upon the result: that is, one factor became the controlling factor and dictated the rate of corrosion, providing that the other factors were not varied to too great an extent. It was well known that in conditions of practice, and in the laboratory, the rate and distribution of oxygen supply often became the controlling factor. That happened more frequently than was sometimes realised.

There was often less corrosion with rustless steel than with, say, wrought iron, or cast iron in salt solutions and industrial waters. In the case of the rustless steel oxygen was not the controlling factor, because there was more oxygen than could be used up.

The author pointed out that in many tests all those metals which could use up all the oxygen supply gave similar corrosion results; those metals which could not gave less. It was necessary when carrying out corrosion experiments, to be clear as to whether or not oxygen was the controlling factor. If metal is tested under conditions at which oxygen is the controlling factor, one is not really testing its true corrodibility, but the rate of access of oxygen to it, and it must not be concluded that this is the rate at which that metal will corrode in other conditions.

Under some conditions one factor only was the controlling factor, and the others could be varied considerably without altering the results of the experiments but that happy state of affairs did not always occur. There were sometimes two or three factors which notably influenced the rate of corrosion, and the question arose as to which one of these should be controlled most accurately. That factor became the controlling factor which permitted of the slowest corrosion.

External Factors.

In divising standard tests some factors were fairly easy to control and some were not. So far as factors external to the metal were concerned (1) It was fairly easy to control accurately the temperature; (2) if accurate results were required the pressure of oxygen must be controlled also and this could be done with little trouble; (3) the hydrogen ion concentration could be controlled initially, but as the experiment proceeded it was a factor over which there was no control; (4) the rate and distribution of oxygen supply could, as a rule, be accurately controlled if one was prepared to control also the temperature and pressure of oxygen. If not there might be considerable differences in the rate of oxygen supply, owing to connection currents; (5) the nature and distribution of corrosion products could not be fully controlled; (6) it was possible to control initially the conductivity of the liquid, but this might change as the experiment advanced; (7) in the case of an acid solution the metal ion concentration would alter considerably; in other cases it might not alter greatly, and (8) the specific nature of the anion would not alter.

The lecturer then showed a diagram of an oxygen absorption apparatus, illustrating how measurement was taken of the amount of oxygen required to corrode a piece of zinc, the rate of the oxygen supplied to the metal's surface being constant; also diagrams of time-corrosion curves obtained with the apparatus. The controlling factor was pointed out in each case.

The question of what were the controlling factors in corrosion was an important one, and it must be remembered that if the conditions were altered the same controlling factor might not exist. Wrought iron, cast iron and steel might corrode at a certain rate if oxygen was the controlling factor, but if the metals were immersed in, say, dilute acid they would corrode at quite different relative and absolute rates, because the controlling factor would be changed.

Summary.

It often happened that the results of corrosion tests were dictated by the external factors and not by the true corrodibility of the metal itself; and it often happened that the true corrodibility was not required to be known except under certain conditions. In the latter case it was quite in order to use a standard test, but it was no good using a standard test to try to find out how the metal would be affected under other conditions.

In considering a scheme of research for standard tests, Dr. Bengough thought it was quite clear that at the present moment it was impossible to design standard tests for many of the ordinary conditions of practice, although he thought the work of Mr. May had got very close in the case of condenser tubes. In this case corrosion was largely determined by films of corrosion products on the metal and not by oxygen supply.

The only hope of obtaining a standard test was by research work of a more accurate type than was usually published in technical journals. This would take time, and he thought it would be necessary to consider carefully what were the controlling factors in each case.

It was possible, he thought, to frame a scheme which could be useful if time and money were available, but he was afraid that under certain conditions it would be impossible to arrive at a really good *acceleration* test. The principal test on which an acceleration test must be based was the discovery of the controlling factor and the intensification of that factor. Acceleration could not be increased beyond a certain limit because if it was other factors would be upset. The extent to which it could be increased could only be determined by accurate research.

He thought, also, that before good results could be obtained a greater knowledge of theory on the quantitative side of the question was required. "We want to know *quantitatively* how the various factors which affect corrosion do actually influence the rate."

New Companies.

Abrafract, Limited, Beulah Road, Owlerton, Sheffield.—Capital £20,150. Manufacturers and merchants of abrasive and refractory materials, etc. Directors: J. Bingley and E. R. Austin.

Kelloyd Metals, Limited.—Capital £35,000 in 30,000 £1 10 per cent. cumulative preferred ordinary and 100,000 1s. deferred ordinary. Directors: T. D. Kelly and E. Digby.

V. H. Marsden & Company, Limited, 388, Harrow Road, Paddington, W.9.—Capital £2,500 in £1 shares (600 preference). Manufacturers of scales and weights carried on at 388, Harrow Road, W. Directors: E. H. and Eleanor M. Marsden.

Victoria Construction Company (London), Limited, 133-134, Moorgate Station Chambers, E.C.2.—Capital £5,000. Ironfounders, etc. Directors: E. R. Cole (permanent governing director) and A. E. Elliott.

Windle Oil-Firing, Limited.—Capital £1,000. Manufacturers of fuel burners, etc. Permanent director: A. E. Windle, "Te Aro," Hampton-in-Arden, Warwickshire.

Publication Received.

The Reactivity of Coke (1) Standardised Method for the Determination of Comparative Values. By J. H. Jones, J. C. King and F. S. Sinnatt. Published under the authority of H.M. Stationery Office, London, Adastral House, Kingsway, London, W.C.1. Price 1s. net. As of outstanding importance to iron-founders interested in testing the coke for use in cupolas, we recommend the close study of the method described in this booklet. The procedure decided upon was to pass CO_2 over heated coke and then to measure the CO evolved, the temperature of the coke being increased by steps of 50 deg. C. actually from 900 deg. C. to 1,000 deg. C. The number of ml. of CO. formed from 100 ml. of CO_2 has been taken as the reactivity value. The final apparatus chosen, whilst complicated, is not beyond the scope of affairs existing in the larger foundry laboratories.

Recent criticisms passed upon the steel industry in the West of Scotland were rebutted by the president of the West of Scotland Iron and Steel Institute at the annual dinner of the society held in Glasgow on January 20. It was stated that so far from plant being obsolete in the West of Scotland it was so efficient as to be unexcelled in the world for meeting the requirements of the shipbuilding and engineering industry. It was indicated that steps have been taken in the past few days to promote the spirit of co-operation between steel-making and shipbuilding interests in the West of Scotland.

Electric Melting.*

By H. S. Primrose, A.M.I.Mech.E.

Introduction.

A few years ago the electric furnace was not regarded seriously by either ferrous or non-ferrous foundrymen, but during recent years great progress had been made, and the advantages of electric melting have been realised to some extent.

The war was responsible for bringing the electric furnace for steel making into prominence very much more quickly than would have been the case under normal conditions, as this type of furnace was particularly suitable for the production of special alloys, and such alloys were in great demand. There was also a large amount of steel scrap available during the war, which was ideal material for electric-furnace practice.

During the last three or four years, the electric furnace for melting brass to be rolled and extruded has been adopted very largely, and it is not generally known that about two-thirds of the world's supply of yellow brass for rolling mills is now being made in one type of electric furnace alone.

Types of Furnaces.

Although there are many different types of electric furnaces now in use for both ferrous and non-ferrous melting, it is only proposed, in this Paper, to deal with three types of electric furnaces for melting, which have proved to be very successful in operation. These types are:—(1) Héroult furnaces for ordinary and alloy steels, (2) Ajax-Wyatt furnaces for melting brass, (3) Ajax-Northrup furnaces for melting special alloy steels, high-copper alloys, nickel-copper alloys, pure metals and high-melting-point metals.

Héroult Furnaces.

In his Paper to the Iron and Steel Institute in September, 1910, on electric-steel refining, Campbell indicated what was afterwards to become an accomplished fact—"that the electric furnace is especially suitable, and will be largely adopted, for any class of work in which raw materials of a high degree of purity are now used."

In the Héroult electric furnace almost any degree of refining of the steel can be effected, and the removal of sulphur, phosphorus and oxygen is especially easy. This is probably due to the following three causes:—(1) The intense heating of the slag, which is the place at which the refining takes place. Owing to this high temperature and the extreme fluidity of the slag, the rate of the refining reaction is very great, because the velocity of reaction rises very quickly for high temperatures, and not in direct proportion to the temperature; (2) the extremely basic slag that can be kept in a very fluid state, and the calcium carbide formed by the action of the arc on the calcareous slag, are especially advantageous for desulphurisation; and (3) the violent motion of the steel which results from the convection currents produced in the bath, due to the two intensely hot areas caused by the arcs below the electrodes, increases the volume of steel exposed to the hot and fluid slag area, and hence the rate of refining.

Types of Héroult Furnaces.

The Héroult electric furnaces are of the type in which the current passes down one electrode through the slag to the metal and thence back through the slag again to a second electrode (taking the case of the single phase furnace) no bottom electrode being used. The size of the furnace depends on the requirements, and the following particulars are of sizes which are now in use.

10-*cwt. Furnace.*—This size of furnace is specially suitable for making high-speed steel or very light castings. The electrodes are graphite, of 5/8 in. diameter. The power used with the furnace varies from 200 to 400 k.v.a. With the latter a heat can be made in from 1¼ to 1½ hours. The furnace is arranged so that the body can be removed and replaced by a spare body already lined and kept in readiness, so that no delay is necessary for repairs.

1½- *to* 2-*ton Furnace.*—A furnace of this size is suitable for making high-speed and other tool steels, special steels of which comparatively small quantities are required, and small castings. It is of the three-phase type with three electrodes, and the electrodes are of graphite, usually of 6 in. diameter. The power used with this furnace varies from 450 to 600 k.v.a., and the number of heats per day of 24 hours varies from 5 to 7, according to the power available, the degree of refining, etc.

3- *to* 3½-*ton Furnace.*—This furnace is suitable for making alloy steels and carbon steels, and for steel foundries where a fair proportion of the castings are of medium weight, say, one cwt. or more. High-speed steel is also being made in large quantities in furnaces of this capacity, but many firms do not care to make such large heats of tungsten steels. The transformer capacity varies from 600 to 900 k.v.a., and the output is from four to five heats per day. With transformers of 600 k.v.a. capacity an average of about 80 tons of ingots per week has been maintained over prolonged periods, and, with transformers of more power, output would be correspondingly increased.

For this size of furnace many steel makers prefer to use amorphous carbon electrodes of 14 in. or 16 in. diameter. If graphite electrodes are used they should be of 7 in. or 8 in. diameter. The use of carbon or graphite electrodes depends largely on the supply available and the relative cost. Graphite electrodes are more expensive per ton, but the consumption is only about half that of carbon electrodes. Generally carbon electrodes are preferred for technical reasons, but, on the other hand, graphite electrodes are easier to handle.

6- *to* 7-*ton Furnace.*—This size of furnace is most widely used in both England and in the United States. It is especially suitable where considerable quantities of alloy or carbon steels are required. For this size of furnace carbon electrodes of 18 to 20 in. diameter are recommended, and, if graphite electrodes are used, they should be 9 to 10 in. diameter.

10- *to* 12-*ton Furnace.*—This furnace is of a different design from the other furnaces described, the charging door being placed at the back of the furnace instead of at the sides. Furnaces of this type are being used for making alloy and carbon steels, and also for refining molten steel from open-hearth furnaces. These furnaces are especially useful where large ingots are required. The power varies from 1,800 to 2,400 k.v.a., and, when melting cold scrap, about four heats a day can be made, and, with hot metal, about ten heats can be refined. Furnaces of 15, 25 and 35 tons capacity are also in operation in the United States and on the Continent.

The Héroult furnace resembles most nearly a tilting open-hearth furnace. The arched roof is pierced by two or three electrodes, and the furnace is heated by electric arcs—one between each electrode, and the slag or melted metal beneath it. The Héroult furnaces were first built for single-phase currents, but to-day they are nearly all being operated by poly-phase currents, usually 3-phase circuit of any standard periodicity. All 3-phase types of Héroult furnaces are designed with a circular hearth over which three electrodes are arranged at the corners of an equilateral triangle. In one case a 15-ton furnace is being operated by a 3-phase, 25-cycle current, with a Delta connection, at 100 volts. Under these conditions, the current per phase rises to 12,000 ampères. The electrodes are automatically regulated, and the current is taken from a high-tension circuit and stepped down by means of three 750 or 1,000 kilowatt transformers. Accordingly, a 15-ton furnace takes 12,000 × 100 × 1.73 = 2,076 k.v.a., but as the power factor is between 0.8 and 0.9, it consumes actually 2,076 × 0.85 = 1,760 or say 1,800 kw. A low tapping of about 75 volts is used for finishing, and the capacity of the transformers is reduced in proportion. The output of such a furnace, when melting cold scrap continuously for 5½ days per week, is approximately 5 tons a year for each k.v.a. of transformer capacity, that is, a 600 k.v.a. furnace melts 3,000 tons a year.

Electrodes.

Either amorphous-carbon or graphite electrodes can be used for these furnaces. The conductivity of the latter is about four times that of the amorphous electrodes, so that the electrodes of only ½ in. diameter may be used. The chief advantage of the graphite electrode is its small size and the resultant ease of handling. On the other hand, from the metallurgical point of view, a large electrode is advantageous, as the arc is less localised and a larger area is directly heated. With furnaces of 2 tons capacity, or less, graphite electrodes are usually employed, as the amorphous electrode takes up rather a large proportion of the roof space, and the comparatively small tonnage required can usually be obtained.

The question of relative cost is quite an item, and, unless graphite electrodes are greatly reduced in price, this type of electrode will be unable to compete with the amorphous.

With regard to electrode holders, it may be said that water coolers are placed round the electrodes on the roof and the holders are also water cooled. The holders are hinged, and a great deal of experimental work has been done to obtain a suitable material for their manufacture.

The Soderberg Electrode.

Within recent years a new type of electrode has been put forward known as the "Soderberg Continuous Self-Baking Electrode," and this is an important improvement in the manufacture of electrodes which results in a substantial reduction in the cost of melting steel by electricity, and eliminates the trouble of broken electrodes with its resulting loss and trouble to the steelmaker. The electrode consists of a light steel tube built up with riveted and welded steel sheets arranged so as to provide projecting fins which penetrate the carbon paste which is rammed into the tubes. These fins reinforce the electrode and prevent breakage. The cost of the electrode is about half the cost of best quality amorphous electrodes, and the consumption is slightly less, because the steel plate protects the carbon from oxidation when it enters the roof. By the use of these electrodes faster melting and more uniform heating is obtained, because this electrode does not become pointed and covers a larger area of the bath. Due to this, the roof and sides of the furnace last longer, and the steel is not burnt or oxidised by intense local heating by arcs, which expose and blow aside the slag. This type of electrode being slightly plastic, it takes the exact shape of the electrode holder and so ensures perfect contact, and, consequently, prevents the burning of the electrode holders and the cost of replacement of these is entirely avoided. When using these electrodes two sets are generally provided, which are worked alternately. When it is necessary to lengthen the electrode it is removed from the furnace and allowed to cool while another length of electrode is put into the furnace, the whole operation requiring only a few minutes. The short electrode has then a new length of tubing welded on to the short end and a special paste is carefully rammed into the tube and the electrode is again ready for work.

Cost Items.

Power.—This varies from 650 to 800 kilowatt-hours per ton, according to the nature of the scrap, the material to be made, and the efficiency of the shop.

Labour.—One melter, one helper and one or two labourers are employed on the furnace itself, depending on its capacity.

Electrodes.—The consumption of amorphous electrodes is usually from 30 to 40 lbs. per ton, and of graphite 12 to 16 lbs. per ton.

Repairs.—The life of the roof varies with the size of the furnace and other conditions, and between

* A Paper read before the Lancashire Branch of the Institute of British Foundrymen, Mr. J. S. Glen Primrose presiding. The author is on the staff of the Electric Furnace Company, Limited.

80 and 200 heats can be obtained. The banks of the furnace are generally fettled between the heats, so that they last a considerable time.

Other Charges. — Additions, tools, overhead charges, ladle, etc., vary according to the class of steel being made and the shop conditions.

Operating Details.

In operating an electric furnace for making steel the cold scrap steel is thrown on to the hearth through the door after the furnace has been carefully dried out and heated up, or, in the case of a furnace that is in operation, after the furnace has been fettled from previous charge. When charging is completed the current is switched on and kept as constant as possible, either by hand or an automatic regulator. The metal soon begins to melt, and during this period the flux is added. This consists of a mixture of lime, fluor spar, and iron ore or scale. The slag formed floats on the top of the metal and the chemical reaction of refining takes place. The carbon in the steel scrap is oxidised by the oxygen from the iron oxide in the iron ore or scale, and is given off as carbon monoxide. This gas rising through the bath produces the appearance of boiling, and has the effect of thoroughly mixing the flux and the metal. The silicon, manganese, and phosphorus in the bath are oxidised by the oxygen from the iron oxide. The oxides of silicon and manganese are dissolved in the slag and the oxide of phosphorus combines with the lime to form phosphate of lime, which is also taken up by the slag. A portion of the sulphur oxidises and passes away as sulphur dioxide.

When sufficient time has been allowed for these actions to take place the current is switched off and the slag is run off by tilting the furnace. Sufficient carbon is then thrown in to provide the necessary percentage of carbon in the steel, and a second flux is added of lime and fluor spar. The phosphorus, silicon and manganese have been removed by the first slag, but the bulk of the sulphur and a certain amount of iron oxide still remain. This iron oxide is soluble in the second flux, and is removed by the addition of finely powdered carbon, such as anthracite dust, which reduces the iron oxide and, at the same time, forms a reducing atmosphere in the furnace. By reducing is meant taking up or absorbing oxygen from any oxide. The sulphur is also gradually taken up by the slag, and, at the end of the second purification, the metal is ready for tapping.

Melting Grey Iron.

The use of the electric furnace for producing grey cast iron has been adopted to a limited extent in America, and furnaces lined with either acid or basic materials have been adopted for this purpose. In the electric furnace, acid or basic, the regulation of the carbon is easy and accurate. The mixing of cast iron and steel in the electric furnace produces the truest semi-steel known, and it lacks the uncertainty of the semi-steel melted in a cupola. In the basic electric furnace there is generally a loss of silicon from 0.1 to 0.2 per cent., but in an acid-lined furnace there is no loss. With a basic-lined furnace the silicon can be increased by the necessary additions of ferro-silicon.

Grey iron can also be produced in the electric furnace by melting mild steel and raising the carbon content of same by the addition of a carburising agent such as coal or charcoal. The process used is similar to melting steel scrap for steel castings, the metal charged being first melted as in making a steel heat. The carburising agent is then added to the surface of the bath, and the latter thoroughly agitated until the required amount of carbon has been absorbed. The desired percentages of silicon, manganese, and phosphorus are obtained by the addition of these elements in the form of the ferro-alloys. The economic factors which govern the possibilitjes of making grey iron by this method are the relative costs of pig-iron delivered in a given district, and the net value of steel and iron scrap which can be obtained in that district.

Ajax Wyatt Furnaces.

The Ajax Wyatt furnace has been the most successful of induction furnaces, and has proved entirely satisfactory for brass melting where the output is sufficient to keep the furnace running continuously. This furnace is now the standard melting equipment for supplying brass rolling mills and extrusion plants. In consists of a cylindrical steel vessel lined with brickwork or rammed refractory material below which a transformer is suspended, the secondary of which is a vertical V-shaped channel arranged so that it passes round the primary winding and iron of the transformer. Heat is generated in this secondary, and the metal is then circulated by electrical forces, so that hot metal is constantly forced out of the secondary and cooler metal takes its place. This mixing effect is due to three forces, namely, convection currents, electric motor effect, and " pinch " effect.

In starting up these furnaces molten metal is poured in to fill up the V-shaped channel or secondary, and then cold metal is charged into the body of the furnace, and, as the metal in the V-shaped channel becomes superheated by the induced current, it circulates upwards out of the channel, and thus melts the metal above it. The usual size of furnace is 600 lbs. capacity, and one charge is melted per hour, with a current consumption of about 220 to 240 kw. per ton. When the furnace is not running, or when it is on stand-by during the week-end, there is always molten metal left in the channel, which is kept molten with a current consumption of about 8 units per hour.

After the furnace has been started and the first heat poured, sufficient molten metal is always left in the furnace to keep the channel filled, and then, after the furnace has been tilted back from the pouring position, the next charge of swarf, scrap or ingots is charged. When the whole of the metal is melted down and has reached its correct pouring temperature, the needles of the instruments will begin to oscillate, owing to the varying conductivity in the channel. This is very interesting and extremely useful, for it indicates the correct pouring temperature of the metal, and so does away with the necessity of having highly-skilled melters.

TABLE I.—*Ajax Wyatt Furnace—Melting 61-39 Brass in Birmingham.*

Wt. of charge. Lbs.	Total time. Hrs.	Mins.	Units used.	Lbs. per unit.	Units per ton.
610	1	0	68	8.98	250
610	1	0	58	10.50	214
610	0	45	58	10.50	214
610	0	44	48	12.70	176
610	0	55	56	10.88	206
610	0	50	52	11.72	191
590	0	49	51	11.56	194
590	0	53	58	10.15	220
590	0	44	53	11.22	199
590	0	55	46	12.80	175
590	0	52	55	10.70	210
590	0	50	50	11.78	190
590	0	58	59	9.67	232
7,790	11	15	712	10.92	206

When pouring the metal from the furnace, the rate of flow of the metal is under complete control, as the tilting of the furnace is carried out by means of a small electric motor. The controller is usually placed in the centre of the turntable, which carries the moulds, and the melter is, therefore, in the best position for observing the casting of the metal into the moulds. The metal in the furnace can be held at any required temperature by means of voltage regulation. The switching operation is very simple, and a single change-over switch is only required, as it is found in practice that only the voltage necessary for giving the full load and that for stand-by, are used.

The electrical design of these furnaces has required a great deal of care, but, in operation, they work with very little trouble, provided the refractory material has been carefully rammed in and properly dried out. The cost of refractories may be below 6d. per ton melted, but this figure can be exceeded if by any chance there is a failure of power supply; a careless preparation of the bottom, or any bad operation of the furnace on the part of the workmen.

The life of the linings varies from two to three months to two or three years, and, as the cost of labour and materials for ramming the bottom is from £30 to £40, this is not a serious item on an output of 600 to 1,200 tons per lining. In fact, some of the furnaces running in this country at the present day have had an output of 3,000 tons per lining, and are still running on the same lining, and in Sweden outputs of 6,000 to 7,000 tons per lining have been obtained.

Although the efficiency resulting from the generation of the heat within the metal itself is remarkable, it has its limitations, as suitable refractory materials have not yet been found to produce lining for metals of high melting point such as nickel alloys, steel, etc. Continuous research is going on at the present time to improve linings, and so widen the field of application of this method of melting.

Another point which requires consideration is the necessity of leaving enough metal in the furnace between heats to fill the secondary channel. This may be objectionable if it is desired to change the composition of the alloys frequently, but brass of different compositions can be melted from day to day, as the change in the composition can be adjusted. A considerable economy in the cost of making brass in this furnace is due to the accuracy of composition which is obtained.

The following figures show typical performances of Ajax Wyatt furnaces in the Birmingham district working under favourable conditions and casting extrusion billets.

The average cost of melting one ton of extrusion brass containing 60 per cent. copper and 40 per cent. zinc in a 600-lb. Ajax Wyatt furnace is as follows:—

	£	s.	d.
Power.—224 kilowatt-hours at 0.75d....	0	14	0
Lining and Repairs.....	0	1	6
Labour.—One man per shift at £5, making 12 tons per week per shift of 12 hours.....	0	8	4
Total	£1	3	10

From this total should be deducted the amount saved by reduction in furnace metal losses when compared with other melting furnaces, say 10s.

The cost of melting in ordinary pit-fires at different works in Birmingham varies considerably, but the following figures are a fair average cost per ton in works making 60-40 brass for extrusion billets under economic conditions.

	£	s.	d.
Coke	0	8	0
Crucibles	0	4	6
Repairs	0	1	0
Labour	1	2	6
	£1	16	0

There is, in nearly all cases, a saving of at least 1 per cent. in the loss of zinc, though methods of calculating losses are so varied that this figure may be different from place to place. There is no doubt that in many works the saving is considerably higher than this figure. The saving of 1 per cent. of zinc with spelter at £35 a ton is equal to 7s. per ton of brass.

After due consideration is given to the savings which are derived from the space saved, which would be required for the storage of coke and the expense of handling ashes, the improvement of working conditions and ease of handling, it will be seen that a reduction of working costs of at least £1 per ton is obtained. The following is a list of the Ajax Wyatt furnaces installed in the various countries up to October, 1927:—

Country.	No. of furnaces.	Total K.V.A.
United States	375	22,760
Germany	106	7,200
Great Britain	32	2,400
France	15	1,125
Other countries.. ..	62	4,080
Total	590	37,565

The total output of these furnaces in all countries is approximately 870,000 tons per annum, and most of these furnaces are of 60 kilowatt capacity, melting about 600 lbs. per hour. The extraordinarily rapid growth of this type of melting is due to the fact that, while

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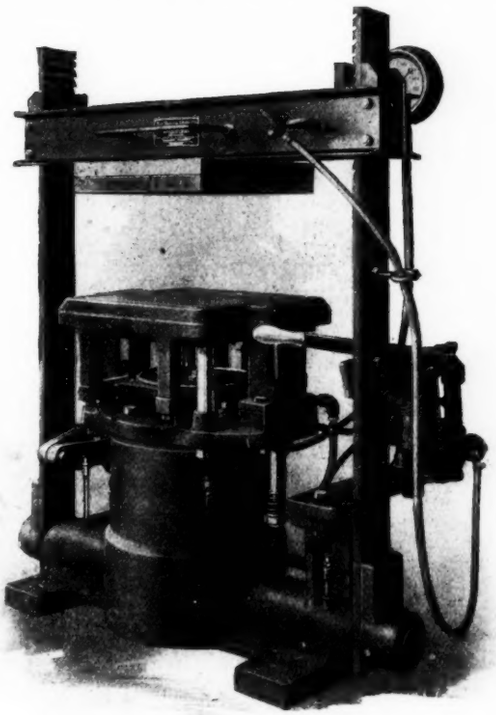

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making a more uniform product, it is also much cheaper to operate than the crucible furnace. The actual cost of power is usually slightly higher than that of the coke used in the crucible furnaces, but the saving in labour, crucibles, and zinc losses far more than counterbalance this cost.

Ajax Northrup Furnace.

This furnace is a newer development of the induction method of heating and uses current of a much higher frequency than the Ajax Wyatt furnace. Ajax Wyatt furnaces are usually run on frequencies of 25 and 50 cycles, but with the Ajax Northrup furnace these frequencies vary from 500 to 20,000 cycles. Until recently difficulty in generating the necessary high frequency current had limited the size of this furnace to a few pounds capacity, and such small high frequency furnaces were of the spark gap type, working about 20,000 cycles. These furnaces have been installed for various purposes, such as research work in laboratories, platinum melting, silica ware manufacture, and the melting of alloys of high purity. Within the last two years, however, motor generators have been perfected which will run furnaces up to 6-cwt. capacity with frequencies from 500 cycles to slightly over 2,000 cycles.

In these furnaces the metal is heated by induction in a high frequency field wherein there is no need of iron or a secondary of the type used in normal high frequency induction furnaces. This has a great advantage metallurgically, as the furnace itself is of very simple construction, consisting only of a crucible round which a spiral inductor coil is wound with a narrow intermediate space filled with zirconite or some other heat insulator. The furnace casing is made of wood, and this body holds the coil which can be either air-cooled or water-cooled, and inside of which is a mica sleeve. The crucible is placed centrally inside the coil, and the zirconite, or other heat insulator, is rammed up round it. The distance between the coil, which is usually at a temperature of about 60 deg., and the molten metal which may be at 1,700 to 1,800 deg. C., is only 0.75 in. in the small type of furnace and in the large 6-cwt. size the distance is about 2½ in. The temperature gradient is accordingly very steep, and the outside of the crucible is only just visibly red when the metal is molten. Hence it is obvious that the wear of crucibles on the outside is very little. In addition to this the crucible is well supported all over its outer surface by the well-packed zirconite, which eliminates any tendency for the crucible to break owing to the weight of the charge.

The life of crucibles in a large number of heats of cupro-nickel and nickel silver was 58, which was increased to 95 by proper fettling between heats, but it was found to be doubtful whether the delay caused by this patching or fettling was justified by reduced costs. The cost of high frequency furnace melting is about equal to that of a small Héroult arc furnace, as the power consumption, including all losses, is about the same, and the extra cost of crucibles is approximately equal to that of electrodes.

Steel made in this furnace is made under crucible conditions, but with the advantage that absolute homogeneity is obtained due to the intensity of the mixing. Heating and melting are effected very rapidly, as induction heating makes it possible to generate heat throughout the charge of metal simultaneously, instead of heating from the surface only, as is the case with all fuel furnaces. For melting operations and the heating of bars this is sometimes advantageous, as the risk of oxidation and contamination from furnace gases is reduced, and, for making small castings, the frequent melting of small quantities facilitates economy in general foundry practice. As an example of speed it is possible to melt 18 per cent. tungsten steel, 3-cwt. lots, in 45 minutes, which is less than one-quarter of the time normally required to melt one-third of this charge in a crucible in a coke fire.

As compared with pit fires this furnace has the advantage of avoiding all contamination with sulphurous fumes and other impurities. Labour costs are reduced and skilled casters of exceptional strength are unnecessary, while absolute control of heat and complete mixing are obtained. The space occupied by coke or ashes is no longer required, while chimney and furnace repairs are eliminated. Crucible costs are reduced to a fraction of those of pit fires, but, on the other hand, capital expenditure is considerable, and a skilled electrician is required for the rotary machinery.

Table II.—*Ajax Northrup Furnace—High-Frequency.*

Material.	Wt. of charge. Lbs.	Total time. Hrs. Mins.	Units used.	Lbs. per unit.	Units per ton.	Remarks.
Nickel silver	636	1 49	163.8	3.98	563	Cold crucible
,, ,, ...	636	1 18	121.8	5.23	428	Hot ,,
Common brass	636	1 4	105.5	6.02	372	Cold ,,
,, ,, ...	636	0 43	71.3	8.90	252	Hot ,,
Copper	636	1 9	115.0	5.53	405	Hot ,,

Table III.—*Ajax Northrup Furnace—High-Frequency.*

Material.				Wt. of charge. Lbs.	Total time. Hrs. Min.		Lbs. per unit.	Units per ton.
Cu.	Ni.	Zn.	Pb.					
80	20	—	—	440	0	57	3.79	591
80	—	20	—	660	1	1	4.83	464
85	—	15	—	660	1	18	4.22	531
90	—	10	—	660	1	11	3.86	580
64.5	18	17.5	—	660	1	6	4.30	521
61.5	—	37	1.5	660	0	57	5.55	405
65	—	35	—	660	0	58	5.49	408
63.5	15	21.5	—	680	1	1	4.83	464
67	19.75	13.25	—	660	1	17	3.85	582
65	10	25	—	660	1	7	4.48	500

The refining and purification of steel in high-frequency furnaces is a question that is receiving much attention. In many cases tool-steel makers have no desire to refine, but there are cases of interest, notably in connection with heat-resisting steels and alloys, in which absence of carbon is desired. It has sometimes been supposed that refining would not be possible in this type of furnace owing to the comparative failure of the old induction furnaces of normal or low frequency, which have a bath of complicated form with narrow channels, an excessive slag line on the refractories, and which work with low-temperature slags. The arc furnace is an efficient refiner owing to its high slag temperature, but it is only when successive particles of steel are brought into contact with hot slag that refining occurs, and the speed of refining necessarily depends upon the rate at which the impure steel is submitted to the refining action of the lower slag surface.

Table IV.—*Ajax Northrup Furnace—High-Frequency.*

Material.	Wt. of charge. Lbs.	Total time. Hrs. Mins.	Units used.	Lbs. per unit.	Units per ton.
Stainless steel ..	336	0 52	116	2.91	770
Carbon steel ..	400	0 54	140	2.86	783
High speed steel..	450	0 58	154	2.93	764
High speed steel..	450	0 50	149	3.02	742
High speed steel..	450	0 50	148	3.04	736
High speed steel..	450	0 48	150	3.00	743
High speed steel..	450	0 50	160	2.82	794
Nickel iron ..	336	1 30	167	2.05	1,092
Nickel iron ..	336	1 5	125	2.72	823
Nickel iron ..	336	1 10	131	2.60	861

In high-frequency furnaces the electric current causes a very rapid rotating movement of the metal in the vertical planes, the speed of rotation being so great that in a bath of steel 15 in. in diameter the centre of the bath rises more than 1 in. above the circumference. This rapid circulation of the metal in contact with the slag refines the metal, the heat transference between the metal and slag being sufficient to maintain the latter in a fluid condition and to ensure that intimate contact which is so essential to rapid and efficient refining. For example, a bath of steel containing 0.7 per cent. of carbon was left in contact with a slag containing iron oxide for 10 minutes, and the carbon was reduced to 0.24 per cent.

The remelting of low-carbon chromium steels without any increase of the carbon contents is an industrial application of the utmost importance for the recovery of scrap, stainless iron and heat-resisting alloys. The remelting of these alloys without absorption of carbon or impurities from furnace gases has now become a commercial possibility. The following analysis of a stainless-iron ingot made from carbon-free ferro-chrome and a Swedish iron of exceptional purity indicates that very low carbon alloys can be made without difficulty, *e.g.*, chromium 13.5 per cent., carbon 0.03 per cent.

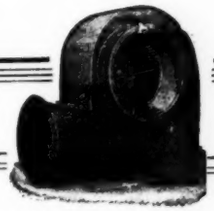
Installations for the manufacture of tool steel usually consist of furnaces of 400 to 500 lbs. melting capacity and each supplied with 150 k.v.a. from a motor generator, the power factors of the furnace being corrected by condensers. The output of such a furnace is about 450 lbs. per hour, or about 4 tons per 24 hours, the exact output depending upon the quality of the steel made and the number of ingots cast. The furnaces are placed below the working platform so that the top of the furnace is on floor level, which is convenient for charging and for slag removal before casting. The ingots or moulds are arranged so that the steel is cast direct from the nose-tilted furnace, a tundish being used to avoid cutting the moulds. The moulds are placed so that their tops are at the same level, and, when a number of small ingots have to be poured, the moulds are brought before the spout of the furnace at the correct level and distance by a suitable turntable and ball bearings. A spare body consisting of a wooden box with spare coil, crucible and refractory sand is provided and can be put in position in a few minutes when it is necessary to change crucibles.

Another typical application is the use of these furnaces in foundries making small castings. For example, a foundry making motor-car castings, where the average weight is between 2 and 3 lbs., can reorganise the system of moulding and general layout so that the moulds can be brought up to the furnace or furnaces on a travelling conveyor, and so ladles and hand shanks can be eliminated. There is no loss of heat by transfer to a ladle or hand shank, and the furnace being well heat-insulated keeps the steel hot through the casting period. For small repetition work this method of melting and casting offers obvious advantages.

It is interesting to compare the effect of stand-by losses on an Ajax-Wyatt furnace with the conditions when operating an Ajax-Northrup furnace, which has no stand-by losses during idle hours, but has a lower overall efficiency for the conversion of energy from the electrical supply main to useful heat units. In the latter case high-frequency energy is generated by a motor generator which has an efficiency of only about 72 to 82 per cent., according to the size or periodicity of the machine, the additional loss in the furnace itself reducing the overall efficiency to about 60 per cent., against 83 per cent. for the Ajax-Wyatt furnace. If the two furnaces be worked 8 to 10 hours per day for 5½ days per week, it will be found that the Ajax-Northrup high-frequency furnace is about equal in efficiency and possesses sufficient marked advantages for numerous difficult metallurgical operations. The capital expenditure per kilowatt installed is approximately the same for the two furnaces, and the operating cost of the Ajax-Wyatt furnace is lower for continuous operation.

The scope of high-frequency melting is expanding as rapidly as electrical machinery constructors can meet the requirements imposed upon them, and progress both in the melting and heating of ferrous and non-ferrous materials is being rapidly accomplished. Its value is already well established as a method of making crucible steel, nickel-copper alloys, high-copper alloys, metals requiring great purity, and high melting-point metals of remarkable homogeneity and purity, with the elimination of the hard physical labour inseparable from present methods.

XUM



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Trade Talk.

William Heap & Partners, Limited, Royal Liver Building, Liverpool, have removed to 319, New India Building, Water Street, Liverpool.

The Hendy Hematite Iron Ore Company, Limited, are being wound up voluntarily. Mr. A. Bassett, 59, Waterloo Gardens, Cardiff, has been appointed liquidator.

Pipes, Limited, 34, Fenchurch Street, London, E.C.3, have been formed for the sale of cast-iron gas and water pipes, etc. Mr. A. S. Arup is the managing director of the company.

Mr. Gordon Perry, of Toronto, acting on behalf of the syndicate of international steel and banking interests, has purchased the plant at Toronto of the Baldwin Steel Company. The plant has been idle for several years.

Joseph Kaye & Sons, Limited, Lock Works, Leeds, have recently secured contracts for a year's supply from all sections of both the L.M. & S. & L. & N.E. Railways for railway carriage door locks and handles. The company also have contracts in hand for the Great Western, Union of South Africa, Great Southern of Ireland, and Iraq Railways.

Elliott's Metal Company, Limited, announce that the offer of Imperial Chemical Industries, Limited, to purchase the ordinary shares of the former company has been accepted by the holders of considerably more than 75 per cent. of the shares of this class. The scheme, therefore, is now an accomplished fact.

Hadfields, Limited, Sheffield, have recently booked another order for one of their large cast-steel framed stonebreakers, fitted with "Era" manganese steel jaws, checkplates, etc. The weight of the machine is 46 tons, its capacity is 100 to 120 tons per hour, and when installed it will be the largest crushing machine operating in New Zealand.

It is reported that the directors of the London Metal Exchange have decided that, beginning early in March, the afternoon sessions, which were stopped at the outbreak of the war, shall be resumed. At present the exchange is in session for little more than one hour daily, closing at 1.20 p.m., and consequently considerable inconvenience has at times been experienced by brokers.

The order for electric traction equipment recently placed by the London Underground Railways with the General Electric Company, Limited, of Magnet House, Kingsway, London, W.C.2, has been very considerably increased and now comprises in all 920 traction motors, each of 240 H.P. capacity, and "automatic acceleration" control equipment for 63 motor coaches and 107 trailer cars. This is the largest single order ever placed in this country for electric railway motors.

The quarterly ascertainment that governs the wages of the employees in the works of the South Wales Siemens Steel Association for the period ended December 31 last of the average price of steel bars, just received, shows the figure to have been £5 11s. 0½d. per ton, f.o.t. makers' works, which is equivalent to 5 per cent. under the shifting scale. This ascertainment will govern wages comparable for the current quarter, and compares with 6¼ per cent. in the previous ascertainment. Men in certain grades, however, are in receipt of an ex gratia bonus in addition to the sliding scale.

Negotiations for the purchase by Joseph Foster & Sons, Preston, of the works and plant of Yates & Thom, engineers and boiler makers, of Canal Foundry, Blackburn, have been completed. The Blackburn firm, who were recently wound up voluntarily, had been in existence for over a hundred years, and the works provided employment for a thousand persons. Foster & Sons employ about six hundred persons. The senior partner in Foster & Sons has stated that excepting the engineering section all parts of the Blackburn Foundry would be working within a fortnight, finding employment for over 200. The staff would be increased gradually.

The Sté. Ame. d'Athus-Grivegnée have amalgamated with the Sté. Ame. des Aciéries d'Angleur et des Charbonnages Belges, under the title of Sté. Ame. d'Angleur-Athus. The interests of the two Belgian companies in the United Kingdom are now entirely represented by the Angleur-Athus Steel Company, Limited, Staple House, 51-52, Chancery Lane, London, W.C.2. Mr. A. d'Heur and Mr. P. Greiner, respectively general manager and commercial manager of Sté. Ame. d'Angleur-Athus, have been elected as directors of the company. Mr. H. A. Dubar, who has been managing director of the Athus Grivegnée Steel Company, Limited, since its inception, will continue to be managing director of the Angleur-Athus Steel Company, Limited. Mr. E. S. Baker, of 31-33, High Holborn, who has been the London representative of the Sté. Ame. des Aciéries d'Angleur, has been appointed manager, with Mr. Eugène Dubar as assistant manager. Mr. H. A. Alliston will continue to be secretary of the company.

Plans have been passed at the Falkirk Dean of Guild Court by Walker, Hunter & Company, Limited, for extensive reconstruction, etc., of their Portdownie Ironworks. The cost of the work is estimated at about £30,000.

The plant at the Ironworks of S. H. Burrows & Sons, Limited, Sheffield, has been acquired for dismantling purposes by Thos. W. Ward, Limited, Sheffield, who have made a speciality of dismantling works. For over 60 years Burrows' bar iron has been famous for its quality, the output being something like 700 tons per week, and seeing that they rolled a large number of special sections required for various trades, the closing of their works may cause some inconvenience to manufacturers. The plant comprises twenty-two puddling furnaces, five steam hammers, seven rolling mills, including two modern 10-in. and 9-in. rolling mills 3 high, each electrically driven by 350-h.p. motor; the two latter mills have been used for rolling steel, and these will no doubt be installed for re-use in other works.

The Fairfield-Howden Ruths Steam Accumulators, Limited, have now completed the work for which they were formed, namely, to introduce Dr. Ruths' inventions to the British steam consumer. On this foundation a new company has now been formed to pursue and extend on a large commercial scale the construction and use of steam accumulators in all parts of the British Empire. The board of this new company, Ruths Steam Accumulators, Limited, is as follows:—Chairman, Mr. F. E. Powell, chairman of the Anglo-American Oil Company, Limited; directors: Sir Alexander Kennedy, chairman of the Fairfield Shipbuilding and Engineering Company, Limited; Dr. Johannes Ruths, inventor of the accumulators, Stockholm; Mr. J. B. E. Dahlerus, managing director of the Electrolux, Limited; Mr. J. Howden Hume, chairman of James Howden & Company, Limited; Mr. W. S. Eyre, a director of Grace Bros., Limited; and Mr. A. J. T. Taylor, managing director of the Underfeed Stoker Company, Limited.

Personal.

Mr. J. F. Wright, of Chapeltown, who recently retired from the position of manager of the pattern department at the Thorncliffe Ironworks, was on January 21 the recipient of a presentation. Mr. T. V. Miles, general manager of the Thorncliffe Ironworks, who made the presentation on behalf of the officials and colleagues, referred in highly appreciative terms to Mr. Wright's 40 years' service at the Thorncliffe works.

The council of the Institution of Electrical Engineers have made the seventh award of the Faraday Medal to Professor J. A. Fleming, honorary member of the Institution. Professor Fleming, who is well known as the inventor of the first wireless valve, was Professor of Electrical Engineering in the University of London from 1910 until his retirement in 1927, and has played a notable part in the development of a great many applications of electrical science.

Swan, Hunter & Wigham Richardson, Limited, of Wallsend-on-Tyne, state that the report to the effect that Mr. Henry M. Glass, general manager of Workman, Clark & Company's shipyards at Belfast, had been appointed to the board of directors of Swan, Hunter & Wigham Richardson, with special charge of the Clyde yards of Barclay, Curle & Company, Whiteinch and Scotstoun West, of which firm Mr. Glass would, it was added, also be a director, is entirely unauthorised and inaccurate.

Sir A. George Hadcock, who has for some considerable time past been the head of the famous Elswick Works, and who is one of the directors of the new firm, Vickers-Armstrong, Limited, has now been transferred to the head offices of the combine in London. Sir George is succeeded as managing director of the firm at Elswick by Commander C. W. Craven, R.N., O.B.E., who, after a distinguished career in the Navy, joined Vickers, Limited, and five years ago, having been appointed to a seat on the Board, took up the duties of managing director at Barrow.

Wills.

Hewitt, A. F., West Kirby, iron merchant £5,861

Jones, W. E., Lyndhurst Gardens, Hampstead, a director of Bayliss, Jones & Bayliss, Limited £157,480

Slack, W. H., of Limefield Street, Accrington, Lancs, partner in Henry Slack & Sons, gas-boiler manufacturers £10,253

MacTavish, P. D., Moray Park, Inverness, director of Rose Street Foundry and Engineering Company, Limited £5,099

Wild, P., for many years manager of the armour plate department of Cammell, Laird & Company, Limited, Sheffield ... £8,511

Contracts Open.

Belfast, February 8.—(1) Iron; (2) iron castings; (4) bolts, spikes, etc.; (5) tyres and axles; (6) springs, steel and files; (7) nails, screws, etc.; (8) carriage fittings, for 12 months from March 1, for the Belfast and County Down Railway Company. Mr. H. E. Mellor, secretary, Queen's Quay Terminus, Belfast. (Fee 1s. each.)

Chatham, February 13.—Sewer ironwork, etc., for 12 months commencing April 1, for the Town Council. The Borough Surveyor's Office, Town Hall, Chatham.

Ennis, Ireland, February 6.—(4) Pipe line, (a) steel mains, (b) cast-iron spigot and faucet lead jointed, (c) cast-iron turned and bored, and (d) cast-iron pipes. European manufacture, for the Urban District Council. Mr. F. D. Ball, the engineer, Town Hall, Ennis, Co Clare. (Fee £3 3s., returnable.)

Hull, February 13.—(g) Pinion wheels, gear wheels, steel tyres, truck parts, brake gear, etc.; (h) bolts and screws; (j) nuts, washers, split pins; (k) iron stanchions, lead-coated iron hoods, brass tubing, iron and steel tubing; (n) iron and steel; (p) white metal, block tin, spelter; (s) copper wire and strip, steel binding wire, dynamo tape, copper segments, commutator rings, etc.; (t) overhead equipment material, etc., for 12 months ending March 31, 1929, for the Tramways Committee. The General Manager, Tramways Offices, Albion Street, Hull.

Ilford, February 6.—(5) Iron castings for 12 months ending March 31, 1929, for the Corporation. Mr. H. Shaw, borough engineer and surveyor, Town Hall, Ilford.

Larne, February 9.—Supplying and laying 187 yds. of 3-in. cast-iron water pipes, with the necessary hydrants, fountains, valves, etc., for the Larne Rural District Council. Mr. S. Robinson, surveyor, Victoria Street, Larne.

London, E.8, February 8.—(5) Iron and ironmongery; (8) sewer ironwork, from April 1, for the Hackney Borough Council. Mr. P. Holt, borough engineer and surveyor, Hackney E.8. (Fee £1 1s., returnable.)

London, S.E.1, February 17-March 6.—(9) 20 tons of ferro-manganese and (10) seven spans of 350 ft., for the India Store Department, Belvedere Road, Lambeth, S.E.1. (Fee 5s. for each schedule, non-returnable.) (Tenders due February 17 for (9) and March 6 for (10).)

London, S.E.14, February 14.—(6) Ironmongery and iron castings for year ending March 31, 1929, for the Deptford Borough Council. Mr. A. Purkis, town clerk, Deptford Town Hall, New Cross, S.E.14.

London, S.W.1, February 3.—Girder bridges (40-ft. spans), for the Bombay, Baroda and Central India Railway Company, the White Mansion, 91, Petty France, S.W.1. (Fee £1 each, non-returnable.)

London, S.W.11, February 29.—(10) Iron castings, for the Battersea Borough Council, for three, six and 12 months from April 1. Mr. E. Austin, town clerk, Town Hall, Battersea, S.W.11.

Lourenco Marques, March 15.—Wood-working machines, high-speed steel cutters, etc., for the board of the port and railways at Lourenco Marques. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Reference A.X. 5,829.)

Mitcham, February 4.—(3) Sewerage ironwork for 12 months from April 1, 1928, for the Urban District Council. The Surveyor's Office, Broadway House, Lower Mitcham.

Salisbury, February 15.—Iron castings, etc., for one year from April 1, for the Town Council. The City Engineer, Endless Street, Salisbury.

Southport, February 13.—(4) Iron castings (manhole covers, special castings, etc.), smithy iron, etc.; (5) bolts, nuts, galvanised goods, screws, nails, etc., for the year ending March 31, 1929, for the Corporation. Mr. A. E. Jackson, borough engineer and surveyor, Town Hall, Southport.

Swansea, February 11.—Iron and steel manhole covers and frames, gullies and frames, lamp pillars, etc., for six or 12 months from April 1, for the Town Council. The Borough Engineer and Surveyor, Guildhall, Swansea.

Obituary.

Mr. C. Day, who was well known in the lift engineering trade and by his connection with Waygood-Otis, Limited, lift makers, died recently. His father, the late Mr. J. M. Day, with Mr. H. C. Walker and the late Mr. W. R. Green, purchased the business from Mr. Richard Waygood in 1875. Mr. Charles Day became a partner in 1887, and when the business was made a limited liability company he was elected a director. An amalgamation was made with the Otis Elevator, Limited, in 1914, and the trading name was then changed to Waygood-Otis, Limited.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The prospects of an improvement in iron trade conditions in the Cleveland district, foreshadowed in recent market reports, have since been confirmed by increased activity in demand for both home and export, and now that business is settling down to normal proportions, optimistic views appear likely to be justified in the near future. First, it will be noted that stocks of pig accumulated in the recent slack period have already diminished in makers' yards, a process indicating that demand is steadily overtaking production, and pointing to the probability of an early increase of furnace outputs as essential to meeting the future requirements of consumers. Another hopeful factor in the position is that English foundries appear to be using more iron, but there is still no disposition to buy far ahead, and most of the sales are for early delivery. Export houses report that there are more inquiries from abroad, but as yet few of these have resulted in actual business being placed. Prices in this district are all firm and unchanged as follow:—No. 1 Cleveland foundry iron, 67s. 6d.; No. 3 Cleveland G.M.B., 65s.; No. 4 foundry, 64s.; No. 4 forge iron, 63s. 6d. per ton.

The outlook in the East Coast hematite market appears also a shade more promising, and makers are inclined to a firmer attitude as regards prices. Since the New Year there have been sales at very low prices, but in some cases 70s. per ton has been the makers' minimum for East Coast mixed numbers. In other directions, however, business can still be placed at 69s. for anything more than 10- or 20-ton lots, with No. 1 quality at 76s. 6d. No change has been marked in prices on the North-West Coast, which remain at 70s. per ton for Bessemer mixed numbers.

LANCASHIRE.—So far as the current month's trading in foundry pig is concerned, there has not been any marked improvement in local demand, which continues quiet, with a disinclination on the part of consumers to consider forward buying. Prices, however, remain fairly steady, with Staffordshire brands quoted at round 72s. 6d. per ton for delivery in the Manchester district, Derbyshire No. 3 at 73s., Cleveland at 78s., Scottish at 87s. 6d., and West Coast hematite at 84s. 6d. to 85s.

THE MIDLANDS.—Current reports from the chief centres of industry in this area indicate that the iron-founders in the Black Country are anything but busy, and show little inclination to enter into contracts for forward delivery. For the present the makers are holding out strongly for current prices, quoting for Northants No. 3 60s. at furnaces, Derbyshire No. 3 64s. to 65s., with North Staffordshire also at the latter price.

SCOTLAND.—Production of foundry pig in the Scottish area is still in restricted volume, the demand continuing on an unsatisfactory scale, with prices unchanged on the basis of 70s. per ton f.o.t. furnaces for No. 3 quality.

Finished Iron.

Despite the optimistic views expressed in influential banking quarters and by other eminent trade authorities, the finished iron industry continues quiet and disappointing in volume, and mills in the Black Country are but poorly off for new business. In the case of the cheaper grades of iron, Continental competition precludes any revival, and the present state of affairs will continue to operate whilst the disparity in price remains. At the moment nut and bolt iron is offered locally at £8 17s. 6d. to £9, but the Continental product is obtainable quite freely at £5 17s. 6d. delivered Black Country works. The orders passing through to the works for crown iron do not represent much tonnage, being very miscellaneous indeed. Quotations continue to vary to a considerable extent, and anything from £9 5s. to £10 10s. is quoted for alleged crown iron. Marked bars are quoted at £12 10s. at makers' works, and the makers of this class of iron continue to be fairly well engaged.

Steel.

Reports from Sheffield manufacturers indicate little general improvement in the staple industry, but the demand for rail billets is slightly more active. Basic billet buying is on only a small scale. Prices are unchanged at £10 for Siemens acid billets, £8 2s. 6d. for hard basic, £7 12s. 6d. for medium, £7 10s. for semi-hard, and £6 10s. for soft. Acid open-hearth steel is in fairly good request, and the demand for special steels keeps up well. The cheaper classes of steel are sagging rather badly, with orders on only a small scale. Inquiries for tinplates are fairly numerous, but buyers are difficult to deal with at anything over 17s. 9d., and at this figure there are very few, if any, sellers; 17s. 10½d. is being paid for good lines, and in some cases 18s., but, generally, buyers hesitate to commit themselves ahead to any extent.

Scrap.

From impressions gained in a survey of conditions existing in the scrap metal trade in most districts, there would appear to be a more active buying movement on the part of consumers, and prices are evidently gaining a little strength, especially in the north. In Scotland notably the demand for foundry material has improved of late, machinery quality, in pieces not exceeding 1 cwt., being firm at 67s. 6d. to 70s. per ton, with heavy ordinary cast-iron scrap to the same specification 62s. 6d. to 63s. 6d. per ton, and light cast-iron scrap at 55s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works. At Birmingham the majority of the local foundries are now busy, and dealers have no difficulty in realising 70s. per ton delivered for heavy cast-iron scrap, and 50s. to 53s. per ton delivered for the lighter qualities. There is a good demand for cast-iron borings, however, at 27s. 6d. per ton f.o.t.

Metals.

Copper.—Last week's top price of £63 and over for standard copper constituted a record level for recent years, and, although followed by a slight reaction, may be accepted as a fairly confident market estimate of the stability of the position. This movement has evidently been stimulated by more active buying on consumptive account, with cable makers in the market for fair quantities of wire bars, which were taken for forward arrival at £66 15s. c.i.f. U.K., while the most striking feature has been the enlarged European consumption.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £62 10s. to £62 11s. 3d.; Friday, £62 8s. 9d. to £62 10s.; Monday, £62 13s. 9d. to £62 15s.; Tuesday, £62 16s. 3d. to £62 17s. 6d.; Wednesday, £62 15s. to £62 16s. 3d.

Three Months: Thursday, £62 2s. 6d. to £62 3s. 9d.; Friday, £62 1s. 3d. to £62 2s. 6d.; Monday, £62 2s. 6d. to £62 3s. 9d.; Tuesday, £62 5s. to £62 6s. 3d.; Wednesday, £62 3s. 9d. to £62 5s.

Tin.—In this section of the market also slightly more active conditions have developed, the standard cash position showing a slight improvement. The statistical position, however, does not conduce to optimistic views of the more immediate outlook. The figures issued at the end of December indicated a fairly healthy position, the visible supply being no larger than it was a year previous, but there is no ignoring the fact that particulars of the mine output on the whole showed a large increase for the past year estimated at over 12,000 tons. At the reduced level good buying was attracted, and prices recovered.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £250 10s. to £250 12s. 6d.; Friday, £251 to £251 5s.; Monday, £249 15s. to £250; Tuesday, £247 7s. 6d. to £247 10s.; Wednesday, £245 15s. to £246.

Three Months: Thursday, £250 to £250 2s. 6d.; Friday, £250 5s. to £250 10s.; Monday, £249 10s. to £249 15s.; Tuesday, £247 5s. to £247 7s. 6d.; Wednesday, £245 15s. to £246.

Spelter.—Following a slightly better demand from galvanisers, values of ordinary spelter have advanced. The position has also been helped to a certain extent by the moderation of sellers, who have certainly not pressed offers on the market. Continental consumers are not buying heavily at the moment.

The following are the week's prices:—

Ordinary: Thursday, £26 8s. 9d.; Friday, £26 8s. 9d.; Monday, £26 5s.; Tuesday, £26 2s. 6d.; Wednesday, £26.

Lead.—In the market for soft foreign pig, an outstanding feature has been the steady demand for April lead on the part of prominent dealers, which has tended to keep values on the firm side in forward positions. So far as can be gathered, home consumers are not well covered, and a revival of buying is considered about due, particularly on the part of cable-makers.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £21 13s. 9d.; Friday, £21 11s. 3d.; Monday, £21 2s. 6d.; Tuesday, £20 17s. 6d.; Wednesday, £20 17s. 6d.

Chemical Testing of Iron and its Alloys.

In the course of a Paper read by Dr. E. Schiffer, of Essen, at the recent Congress on Testing Materials, held in Berlin, he pointed out that in analytical determinations carried out in the chemical laboratories of ironworks the large quantities of iron samples must be taken into consideration. They were nearly always weighed specially for each determination, which enabled a large number of analyses to be carried out more expeditiously in series. By preventing the separation of the iron, and by employing volumetric analysis, rapid processes had been developed for a number of constituents, and by means of them exact results could also be obtained empirically. It was no longer possible to dispense with such processes in controlling the melts in the producing works. Both in determining the nature of the raw materials and in obtaining manufacturing materials of definite chemical composition, the chemical test was therefore of the utmost importance.

When judging figures of analysis (continued the author), account must be taken of the limits of error due to the method of working. Differences in analysis as between producers and users of material are most frequently due to differences in the method of taking the samples for testing. The accurate taking of samples so that they may represent the average composition of the material, is difficult, because the various constituents are irregularly distributed throughout the material. One of the chief causes of this is segregation. The nature of the distribution of the elements can be ascertained with precision only by taking test chips from borings systematically over the section of an ingot which has been sawn through. In the case of all rolled products, the samples should not be taken by drillings from the outside if the analytical results are to show the average composition of the steel, but by planing over the entire cross-section.

Further causes of irregularity in the chemical composition may be due to the wrong treatment of the steel before it is finished. Decarburisation is caused more particularly by overheating and burning the metal. The absorption of carbon in case-hardening, for instance, as well as cementation with gaseous carbonising media, may produce irregularity. Similarly, nitrogen and aluminium may be irregularly distributed in nitrified and aluminated articles. Irregularities affecting the analytical results may also arise in the taking of samples. Thus, when weighing grey pig-iron or cast-iron chips, attention should be paid to the change which may have taken place in the distribution of their graphite content. In taking samples it is also important to exclude oil, dust and other impurities containing carbon.

Protection of Steel Sewer Pipes.—Mr. Measham Lee (chief engineer, Karachi Municipality), in his recent presidential address to the annual congress of Bombay Engineers, specially referred to the latest development in the protection of steel pipes. It is the first time that such types of pipes have been used in India—he said—and the 33-in. diameter rising main now being provided in connection with the new drainage works, is a steel pipe with a bitumen lining $\frac{5}{16}$ in. thick. The outer steel shell is $\frac{3}{8}$ in. thick longitudinally welded, with rolled spigot-and-socket joints for lead caulking, externally coated with bitumen and double wrapped with hessian soaked in bitumen. The pipe having been previously heated is rapidly rotated in a special machine and the hot bitumen with suitable filler placed inside, when by centrifugal action the bitumen lining is truly and compactly applied to the inside of the pipe. The cost of the bitumen-lined steel pipe is Rs. 1,25,000 (£9,375), less than the quotation for a cast-iron pipe concrete lined to perform the same duty. The steel pipes were supplied by Messrs. Stewarts & Lloyds, Limited, of Glasgow.

"A QUALITY FOR EVERY REQUIREMENT"

Just for the Job

IN these days when castings have to withstand very definite tests it is essential that pig irons of a regular, reliable quality, and guaranteed analysis, be readily available.

Whatever your requirements may be, you will find a particular quality in the Bradley range of Refined Pig Irons that is just what you want—made for your specific purpose by up-to-date methods with plant under metallurgical control.

BRADLEY'S REFINED PIG IRON *for* MALLEABLE CASTINGS

BRADLEY'S REFINED PIG IRON *for* LOCOMOTIVE CYLINDERS

BRADLEY'S REFINED PIG IRON *for* AUTOMOBILE CYLINDERS

BRADLEY'S REFINED PIG IRON *for* CHILLED ROLLS

BRADLEY'S REFINED PIG IRON *for* HEAT RESISTANCE CASTINGS

BRADLEY'S REFINED PIG IRON *for* HYDRAULIC CYLINDERS

Bradley's PIG IRON

WRITE TO-DAY If you have not received our booklet giving full particulars of Bradley's Refined Pig Irons for every requirement, please write and a copy will be sent by return.

BRADLEY & FOSTER L^TD DARLASTON, STAFFS.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	62 15 0
Three months	62 3 9
Electrolytic	66 10 0
Tough	65 5 0
Best selected	65 10 0
Sheets	92 0 0
India	77 0 0
Wire bars	67 0 0
Do. February	66 15 0
Do. March	66 15 0
Ingot bars	66 15 0
H.C. Wire rods	71 5 0
Off. av. cash, Jan.	61 18 11 1/32
Do. 3 mths., Jan.	61 15 0 15/32
Do., Sttlmnt., Jan.	61 18 10 3/4
Do., Electro, Jan.	66 16 1 7/8
Do., B.S., Jan.	66 4 8 3/4
Aver. spot price, copper, Jan.	61 18 11
Do., Wire bars, Jan.	67 1 1 3/4
Solid drawn tubes	13d.
Brazed tubes	12 1/2d.
Wire	9 1/2d.

BRASS.

Solid drawn tubes	11 3/4d.
Brazed tubes	13d.
Rods, drawn	13 3/4d.
Rods, extd. or rlld.	10 1/4d.
Sheets to 10 w.g.	7 1/2d.
Wire	10 1/4d.
Rolled metal	9 1/2d.
Yellow metal rods	9 1/2d.
Do. 4 × 4 Squares	7 1/2d.
Do. 4 × 3 Sheets	8d.
	8 1/4d.

TIN.

	£ s. d.
Standard cash	245 15 0
Three months	245 15 0
English	245 0 0
Bars	249 0 0
Straits	247 15 0
Australian	248 0 0
Eastern	252 10 0
Banca	248 10 0
Off. av. cash, Jan.	253 6 5 1/32
Do., 3 mths., Jan.	252 5 1 1/4
Do., Sttlmt., Jan.	253 6 4 1/4
Aver. spot, Jan.	253 6 5

SPELTER.

Ordinary	26 0 0
Remelted	26 0 0
Hard	20 10 0
Electro 99.9	30 15 0
English	26 10 0
India	22 0 0
Zinc dust	33 0 0
Zinc ashes	8 15 0
Off. aver., Jan.	26 1 9 3/32
Aver., spot, Jan.	26 2 6

LEAD.

Soft foreign ppt.	20 17 6
English	22 10 0
Off. average, Jan.	21 19 10 13/32
Average spot, Jan.	21 15 5 1/2

ZINC SHEETS, &c.

Zinc sheets, English	35 0 0
Do. V.M. ex whf.	33 0 0
Rods	41 15 0
Boiler plates	30 10 0
Battery plates	32 0 0

ANTIMONY.

Special brands, Eng.	64 10 0
Chinese	45 0 0
Crude	37 0 0

QUICKSILVER.

Quicksilver	22 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	8 17 6
45/50%	12 17 6
75%	20 10 0
Ferro-vanadium— 35/40%	14/3 lb. va.
Ferro-molybdenum— 70/75% c. free	5/- lb.
Ferro-titanium— 23/25% carbonless	11 1/2d.
Ferro-phosphorus, 20/25%	£17 15 0
Ferro-tungsten— 80/85%, c. fr.	1/3 lb.
Tungsten metal powder— 98/99%	1/7 1/2 lb.
Ferro-chrome— 2/4% car.	£32 15 0
4/6% car.	£22 10 0
6/8% car.	£22 7 6
8/10% car.	£22 5 0
Ferro-chrome— Max. 2% car.	£35 10 0
Max. 1% car	£41 10 0
Max. 0.70% car	£53 0 0
70% carbonless	1/2 lb
Nickel—99% cubes or pellets	£175 0 0
Ferro-cobalt	9/3 lb.
Aluminium 98/99%	£105 0 0
Metallic chromium— 96/98%	2/11 lb.
Ferro-manganese (net)— 76/80% loose	£13 10 0
76/80% packed	£14 10 0
76/80% export	£13 0 0
Metallic manganese— 94/96% carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 6
Finished bars, 18% tungsten	£0 3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/2 in. × 1/4 in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d. to £ s. d.
South Wales— Hvy. steel	3 0 0 to 3 2 6
Bundled steel and shrngs.	2 14 6 to 2 18 6
Mixed iron and steel	2 15 0 to 2 16 0
Heavy cast iron	2 18 6 to 3 0 0
Good machinery for foundries	3 0 0 to 3 2 6
Cleveland— Heavy steel	
Steel turnings	2 12 6
Cast iron borings	2 6 0
Heavy forge	2 3 0
Bushelled scrap	3 12 6
Cast-iron scrap	3 2 6 to 3 6 0
Lancashire— Cast-iron scrap	3 5 0
Hvy. wrought	3 2 6
Steel turnings	2 2 6

London—Merchants' buying prices delivered yard.

Copper (clean)	51 0 0
Brass (clean)	38 0 0
Lead (less usual draft)	19 0 0
Tea lead	16 0 0
Zinc	17 0 0
New aluminium cuttings	76 0 0
Braziery copper	47 0 0
Gunmetal	48 0 0
Hollow pewter	170 0 0
Shaped black pewter	130 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast— Foundry No. 1	67/6
Foundry No. 3	65/-
Foundry No. 4	64/-
Forge No. 4	63/6
Hematite No. 1	69/6
Hematite M/Nos.	69/-
N.W. Coast— Hem. M/Nos. d/d Glas.	83/-
,, d/d Birm.	87/-
Midlands— Staffs. common*	—
,, No. 4 forge	62/6
,, No. 3 fdry.	64/- to 65/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—

* d/d Birmingham.

Northants forge	—
,, fdry. No. 3	60/-
Derbyshire forge	60/-
,, fdry. No. 3	64/- to 65/-
,, basic	—
Scotland— Foundry No. 1	—
,, No. 3	70/-
Hem. M/Nos.	74/-
Sheffield (d/d district)— Derby forge	64/-
,, fdry. No. 3	67/6
Lincs. forge	64/-
,, fdry. No. 3	66/6
E.C. hematite	82/6
W.C. hematite	85/-
Lincs. (at furnaces)— Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)— Derby forge	—
,, fdry. No. 3	73/-
Northants foundry No. 3	—
Dalzell, No. 3	100/- to 102/6
Summerlee, No. 3	87/6 to 94/-
Glengarnock, No. 3	87/6 to 94/-
Gartsherrie, No. 3	87/6 to 94/-
Monkland, No. 3	87/6 to 94/-
Coltness, No. 3	87/6 to 94/-
Shotts, No. 3	87/6 to 94/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d. to £ s. d.
Iron— Bars (cr.) nom.	9 5 0 to 10 10 0
Angles	—
Tees to 3 united ins.	—
Nut and bolt iron	—
Hoops	9 0 0
Marked bars (Staffs.) f.o.t.	12 10 0
Gas strip	12 10 0
Bolts and nuts, 3/4 in. × 4 in.	12 0 0
Steel— Ship plates	15 5 0
Boiler plts.	8 2 6 to 8 7 6
Chequer plts.	10 10 0
Angles	10 5 0
Tees	7 12 6
Joists	8 12 6
Rounds and squares, 3 in. to 5 1/2 in.	7 12 6
Rounds under 3 in. to 1/4 in. (Untested)	7 10 0
Flats, over 5 in. wide and up	7 15 0 and upwards
Flats, 5 in. to 1 1/2 in.	8 17 6
Rails, heavy	7 17 6
Fishplates	8 2 6 to 8 7 6
Hoops (Staffs.)	12 10 0
Black sheets, 24g.	10 10 0
Galv. cor. shts., 24g.	10 2 6
Galv. fencing wire 8g. plain	13 0 0
Billets, soft	12 10 0
Billets, hard	£6 0 0 to 6 10 0
Sheet bars	8 2 6
Tin bars	£5 12 6 to 5 15 0
	£5 12 6 to 5 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2 1/2
Sheet to 10 w.g.	1 3
Wire	1 3
Rods	1 3 3/4
Tubes	1 3
Castings	1 8 1/2
	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

Ingots for raising	per lb. 9d. to 1/3
Rolled— To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3 1/2 to 1/9 1/2
To 15 in. wide	1/3 1/2 to 1/9 1/2
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4 1/2 to 1/10 1/2
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5 1/2
Ingots rolled to spoon size	1/- to 1/8 1/2
Wire round— 3/0 to 10 G.	1/6 1/2 to 2/1 1/2

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.26
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.26
Malleable	19.01
Grey forge	18.51
Ferro-mang. 80% d/d	100.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.20
Sheets, black, No. 24	2.80
Sheets, galv., No. 24	3.65
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.25
Tinplate, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	—
Other Districts, foundry	13/6
,, ,, furnace (basis)	12/- to 13/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box 17/10 1/2
,,	28×20 ,, 35/9
,,	20×10 ,, —
,,	18 3/4×14 ,, —
C.W.	20×14 ,, 17/-
,,	28×20 ,, —
,,	20×10 ,, —
,,	18 3/4×14 ,, —
Terneplates	28×20 — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered, £18 10 0 to 19 0 0	
Rolled Ord.	£15 0 0 to £15 10 0
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½% ..	.. 45%
Water	63½% ..	.. 40%
Steam	60% ..	.. 35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Jan. 26 ..	62	10	0	dec.	11/3
,, 27 ..	62	8	9	,,	1/3
,, 30 ..	62	13	9	inc.	5/–
,, 31 ..	62	16	3	,,	2/6
Feb. 1 ..	62	15	0	dec.	1/3

Electrolytic Copper.

	£	s.	d.	
Jan. 26 ..	66	15	0	No change
,, 27 ..	66	10	0	dec. 5/–
,, 30 ..	66	10	0	No change
,, 31 ..	66	10	0	,, ,,
Feb. 1 ..	66	10	0	,, ,,

Standard Tin (cash).

	£	s.	d.	
Jan. 26 ..	250	10	0	dec. 42/6
,, 27 ..	251	0	0	inc. 10/–
,, 30 ..	249	15	0	dec. 25/–
,, 31 ..	247	7	6	,, 47/6
Feb. 1 ..	245	15	0	,, 32/6

Tin (English ingots).

	£	s.	d.	
Jan. 26 ..	249	10	0	dec. 45/–
,, 27 ..	250	0	0	inc. 10/–
,, 30 ..	249	10	0	dec. 10/–
,, 31 ..	247	0	0	,, 50/–
Feb. 1 ..	245	0	0	,, 40/–

Zinc Sheets (English).

	£	s.	d.	
Jan. 26 ..	35	0	0	No change
,, 27 ..	35	0	0	,, ,,
,, 30 ..	35	0	0	,, ,,
,, 31 ..	35	0	0	,, ,,
Feb. 1 ..	35	0	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Jan. 26 ..	26	8	9	inc. 1/3
,, 27 ..	26	8	9	No change
,, 30 ..	26	5	0	dec. 3/9
,, 31 ..	26	2	6	,, 2/6
Feb. 1 ..	26	0	0	,, 2/6

Lead (English).

	£	s.	d.	
Jan. 26 ..	23	5	0	No change
,, 27 ..	23	0	0	dec. 5/–
,, 30 ..	22	15	0	,, ,,
,, 31 ..	22	10	0	,, ,,
Feb. 1 ..	22	10	0	No change

AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 4½
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6½
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 9	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 5½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7½
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 12 6	7 14 1½
1928	7 12 6	—	—	—	—	—	—	—	—	—	—	—	—

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